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"ESTABLISHING OPERATIONAL ACCESS: INSIGHTS FROM THE PAST FOR THE FUTURE"

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DISCLAIMER

The conclusions and opinions expressed in this document are those of the author. They do not reflect the official position of the US Government, Department of Defense, the United States Air Force, or Air University.

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ABSTRACT

The proliferation of antiaccess/area-denial technology is a threat to national security. This study identifies tenets that should guide the Joint Force's development of technology and doctrine to penetrate antiaccess/area-denial defenses. Historical analysis of the role of technology and doctrine in the Battle of Britain, the Combined Bomber Offensive, the Yom Kippur War, and Operation Mole Cricket 19 identifies two tenets that must be incorporated into the next iteration of the Joint Operational Access Concept. First, the Joint Force must identify constraints, assumptions, and context that influence force structure, doctrine, and technology; accurately assess the implications of those factors; and act upon those implications. Second, the Joint Force must take steps to develop the qualities of doctrinal, cognitive, and technological flexibility, which are critical attributes for overcoming war's ever-present challenge of encountering the unexpected. Incorporating these tenets will help the armed services develop an approach for penetrating antiaccess/area-denial defenses that can be employed coherently with the other instruments of national power across a wide range of circumstances. Failure to do so leaves the nation with a Joint Force ill-equipped to further national security.

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Introduction

It is the army that gives weight to diplomatic action, but only so long as it is actually ready and able to intervene when objectives cannot be obtained peacefully.

Helmuth von Moltke

The ability to project power has long been a fundamental element of American national security. Airpower's speed, reach, and flexibility are important aspects of this capability. Early air theorists such as Giulio Douhet and Brig Gen William "Billy" Mitchell understood that the ability to affect targets traditionally unreachable through land or naval combat would change warfare radically. Desert Storm is an example of what airpower can achieve: the thirty-nine day air campaign enabled Coalition ground forces to meet their objectives in approximately 100 hours of fighting. This dramatic victory was a clear indication of the effectiveness of American military technology and doctrine.[1] In response, numerous adversaries have increased efforts to develop technology that can counter the America's ability to project power.[2] Today, it is an open question whether current American force structure and doctrine can expect to achieve the effectiveness demonstrated in Desert Storm.[3]

This is in part due to challenges evolving threats are creating to counter what many perceive to be an American way of war. Everett Dolman describes this mentality as an expectation that American forces can conduct war in a way that is "surgically clean, superbly efficient, and monstrously deadly."[4] The effect of this outlook on the American

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[1] Keith L. Shimko, *The Iraq Wars and America's Military Revolution* (New York, NY: Cambridge University Press, 2010).

[2] Kopp, Carlo, "Evolving Technological Strategy in Advanced Air Defense Systems," *Joint Forces Quarterly*, no. 57 (Quarter 2010): 87.

[3] John V. Bartoli, "Bending the Eagle's Wing: How Advanced Air Defenses Put the Enemy's Vital Centers Beyond the Reach of American Airpower" (School of Advanced Air and Space Studies, Air University, 2010).

[4] Everett C Dolman, *Pure Strategy: Power and Principle in the Space and Information Age* (London; New York: Frank Cass, 2005), 163.

consciousness is such that "the use of force in the world becomes predicated on a calculation of anticipated casualties, economic disruption, and political response."[5] This, in turn, shapes American grand-strategic thought, as well as the corresponding doctrine and force structure to ensure national security. Combat against an intelligent adversary equipped with modern hardware, however, may not be as clean and efficient as our nation has come to expect. The Joint Operational Access Concept (JOAC), a Department of Defense white paper published in January 2012, argues the ability to ensure operational access may be the most difficult challenge US forces will face in the next decade.[6]

Area-denial technologies such as modern Integrated Air Defense Systems (IADS) present a significant challenge to the Joint Force's reach.[7] Features such as increased detection capabilities, extensive engagement ranges, high mobility, and electronic counter measures limit freedom of action in the air domain. One only has to consider the effect recent Iranian efforts to obtain an SA-20 had on Israel's decision making to appreciate how these changes affect national security.

In June 2008 an anonymous US defense official reported to ABC News that Israel was likely to strike Iran by the end of the year. Israel was reportedly focused on two developments, either of which could prompt the strike. The first was Iran's development of sufficient fissile material to create a nuclear weapon. The second was Iran's obtaining and deploying SA-20s from Russia.[8] The implication was that this advanced air defense system would significantly degrade Israel's ability to conduct air strikes on Iranian nuclear facilities. Consequently, American military officials postulated this might put increased pressure on Israel to strike

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[5] Dolman, *Pure Strategy*, 163.
[6] "Joint Operational Access Concept (JOAC)" (Department of Defense, n.d.), ii.
[7] "Joint Operational Access Concept (JOAC)," ii.
[8] Jonathan Karl, "Pentagon Warns of Israeli Attack on Iran," *ABC News*, June 30, 2008, http://abcnews.go.com/Politics/US/story?id=5281043&page=1.

before the system was fielded.[9] As the situation continued to develop, Russia eventually cancelled the sale; and recent diplomatic efforts have decreased the likelihood of an imminent military confrontation.[10] This is merely one example, but it clearly indicates the capacity of modern air defense systems to escalate the anticipated costs of projecting power through the air domain. Adversaries are expanding their efforts to pursue advanced technologies in the other domains of warfare as well, and many are increasing their ability to fight in multiple domains simultaneously.[11] Successfully addressing the challenge of antiaccess/area-denial threats requires developing the ability to integrate capabilities fluidly across domains and among the instruments of national power.[12]

Exacerbating the challenge, the Joint Force must address these threats in what historian Michael Howard calls an "age of peace"—a period in which most people do not believe there will be another major war.[13] To be clear, these periods are not necessarily *peaceful*, as they may be characterized by revolts, internal violence, or other disruptions.[14] Preparing for the next major conflict while it is widely believed no such conflict will occur constitutes a major problem for all of America's armed services. According to Howard, this challenge is exacerbated by two fundamental difficulties. The first is an indifferent or potentially hostile social environment that has little motivation to provide intellectual or economic support to military preparedness. The second difficulty is

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[9] Michael R. Gordon and Eric Schmitt, "U.S. Says Israeli Exercise Seemed Directed at Iran," *The New York Times*, June 20, 2008, sec. Washington, http://www.nytimes.com/2008/06/20/washington/20iran.html.
[10] "Iran Says Tests Own Model of Russian S-300 Missile," *Reuters*, November 18, 2010, http://www.reuters.com/article/2010/11/18/us-iran-military-missile-idUSTRE6AH2YW20101118.
[11] "Capstone Concept for Joint Operations: Joint Force 2020" (Department of Defense, September 10, 2012), 2.
[12] "Capstone Concept for Joint Operations: Joint Force 2020," 2.
[13] Michael Howard, "Military Science in an Age of Peace," *The RUSI Journal* 119, no. 1 (March 1974): 3, doi:10.1080/03071847409421160.
[14] Howard, "Military Science in an Age of Peace," 4.

organizing, training, and equipping one's force without the ability to receive objective feedback on the effectiveness of these activities.[15]

To respond to these challenges, Howard advocates the advancement of "military science" which he defines as the disciplined, agnostic thinking about military affairs.[16] The primary goal of military science is not obtaining better weapons or defenses. Rather, the vital questions military science strives to answer are what do the services *really* need, and why? To answer this question, military science must grasp and contend with both technological feasibility and fiscal capability, but it is primarily concerned with defining operational requirements.[17]

The key to using military science to make such determinations is similar to other scientific thought. The military scientist attempts to separate the constants from the variables and explain what is of continuing validity, while discarding the ephemeral.[18] Although intelligence and foresight certainly hold continuing validity for developing operational requirements, Howard argues flexibility, or, "the capacity to adapt oneself to the utterly unpredictable, the entirely unknown" is of critical importance.[19] Toward this end, this study assesses historical examples of contested operations in order to determine the operational characteristics and types of flexibility that have proven successful in the past.

Given the cost of countering an antiaccess/area-denial threats, it is fair to ask whether pursuing command of a contested domain remains a viable operational construct. It remains clear, however, that the scope of American national interests in the present and foreseeable future

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[15] Howard, "Military Science in an Age of Peace," 4.
[16] Howard, "Military Science in an Age of Peace," 4.
[17] Howard, "Military Science in an Age of Peace." The laws of science bound technological feasibility. The economy and politics govern fiscal capability. Operational requirements are the purview of the military.
[18] Howard, "Military Science in an Age of Peace," 7.
[19] Howard, "Military Science in an Age of Peace," 7.

necessitates the ability to project power.[20] This, in turn, requires the ability to achieve at least some measure of local superiority and freedom of action. Thus, it is important to understand the national and institutional implications of adversaries' ability to contest this capability, especially as antiaccess/area-denial threats continue to advance and proliferate.[21] The Joint Force's challenge in this environment is to *develop an operational construct for penetrating antiaccess/area-denial defenses that is not prohibitive in either cost or risk*.

Two dominant influences shaping any operational construct are technology and doctrine. Technology bounds what is feasible, while doctrine influences both technology's development in peace and codifies the axioms that guide technology's application in war. The insights gained in the study of these two areas will provide incomplete, but still valuable guidelines for the armed services. Ultimately the goal of this work is to determine the tenets that should guide the Joint Force's development of technology and doctrine to maintain the ability to project power across contested domains.

In the search for an effective approach to this challenge, one important consideration is developing a sophisticated understanding of the relationship between technology and doctrine. Technology can push new doctrine, or doctrine can pull new technology. The stirrup is an example of a technological push. This small device had a dramatic effect on medieval society. Lynn White examined how this invention enabled mounted shock combat, a new and highly effective type of warfare. White found that while a new form of combat was important, the effects of the stirrup were much more far-reaching. The fiscal requirements of supporting this type of warfare played a significant factor in developing a

[20] "Capstone Concept for Joint Operations: Joint Force 2020."
[21] "Joint Operational Access Concept (JOAC)."

new societal structure called feudalism.[22] An example of a doctrinal pull on technology is the development of the reconnaissance-strike complex that proved so successful in Desert Storm.[23] Stealth, precision guided munitions and advanced C4ISR were all developed under a broader, but well-established airpower doctrine. The success of this technology-doctrine combination was dramatic. Some authors, such as Keith Shimko, consider it a modern revolution in military affairs.[24] Shimko's is not, however, a universal view. Analysts such as Colin Gray regard technology's promise as a "poisoned chalice" for strategists.[25]

As Stephen Biddle, Wade Hinkle, and Michael Fischerkeller contend, there is a delicate balance between skill and technology.[26] They argue that changing technology may magnify the difference between skilled and unskilled opponents, but skill differential has a far greater effect on outcome.[27] Along similar lines, Colin Gray argues that much of the fog and friction that undoes applied strategy cannot be thwarted by modern technology.[28] Nevertheless, given the nature of projecting power in contested domains, technological solutions will remain an important facet of the Joint Force's approach to contested operations both the near and long terms. The increasing cost of modern systems and the uncertain threat environment will require the armed services to make difficult decisions. An accurate understanding of technology's limitations, as well as an intelligent method to prioritize various doctrinal approaches and supporting technologies, will be important to future combat effectiveness.

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[22] Lynn Townsend White, *Medieval Technology and Social Change* (London; New York: Oxford University Press, 1964), 28.
[23] Shimko, *The Iraq Wars and America's Military Revolution*, 93.
[24] Shimko, *The Iraq Wars and America's Military Revolution*.
[25] Colin S. Gray, "Why Strategy Is Difficult," *Joint Forces Quarterly* 22, no. Summer 99 (August 1999): 9.
[26] Stephen Biddle, Wade Hinkle, and Michael Fischerkeller, "Skill and Technology in Modern Warfare," *Joint Forces Quarterly*, no. 22 (Summer 1999): 24–25.
[27] Biddle, Hinkle, and Fischerkeller, "Skill and Technology in Modern Warfare," 42.
[28] Colin S. Gray, "Why Strategy Is Difficult," 8.

As the Joint Force confronts this problem, it will be important to remember that the narrowing technological gap and its consequences for projecting power are not unique to this generation. We must remember that projecting power in any domain is challenging when contested, but can be particularly problematic for air forces. Airpower's reliance on technology that can be countered and limited ability to close with the enemy continuously can make penetrating antiaccess/area-denial defenses quite difficult.[29] This has significant implications–without the ability to control the air, a force can lose the ability to control the surface.[30] Balancing limited scope with importance of air domain for projecting power, this work's historical analysis focuses on four examples of contested-air operations. They are the Battle of Britain, the Combined Bomber Offensive, the Yom Kippur War, and Operation Mole Cricket 19. These examples were selected based on the common characteristics of a peer-level conflict and the ability to contrast successful defenses with successful offenses. Examining how each side developed, employed, and reacted to various technologies and doctrines will allow the study to determine how these relationships affected each outcome, as well as identify enduring trends.

To this end, Meir Finkel's study of technological and doctrinal surprise offers a useful framework with which to analyze this study's historical examples. Rather than focusing on uncertainty over the location or timing of the next violent conflict, Finkel studies unexpected combat doctrines or weapons systems and the methods through which forces recovered from these surprises. In contrast to many studies that promote the role of intelligence and rely on an accurate forecast of the future battlefield, Finkel argues a force's flexibility is the most important

[29] Colin S. Gray, *Airpower for Strategic Effect* (Maxwell Air Force Base, Ala: Air University Press, Air Force Research Institute, 2012), 281.
[30] Richard P. Hallion, "Air and Space Power: Climbing and Accelerating," in *A History of Air Warfare*, ed. John Andreas Olsen, 1st ed (Washington, D.C: Potomac Books, 2010), 379.

aspect in the ability to recover from being surprised by an unexpected doctrine or technology.[31] Finkel argues, "Flexibility combines doctrinal, cognitive, command, organizational, and technological elements, that if properly applied, can eliminate most obstacles in the current paradigm…"[32] These obstacles include overdependence on a specific concept, group-think, problems inherent in large organizations, relations between intelligence agencies and decision makers, or failure to learn from mistakes.[33] In sum, Finkel advocates that flexibility-based force planning alleviates peacetime obstacles by enabling a force to develop solutions in real time on the battlefield.[34]

Finkel's framework studies the effectiveness of responses to surprise and highlights the elements of flexibility that contributed to recovery or failure. Responses to surprise are judged on a scale of effectiveness. The most effective response results in complete recovery, and generates a new problem for the enemy. The second level of response neutralizes the problem, but fails to develop a new problem for the enemy. The third level of response simply minimizes the damage inflicted by the surprise, while the fourth level is a complete failure to recover. The framework categorizes flexibility into four strata: conceptual and doctrinal; organizational and technological; command and cognitive skills; and ability to learn and disseminate lessons. In the examination each of the historical examples, this study will highlight the nature of surprise each belligerent faced, the level of recovery achieved, and the elements of flexibility that contributed to recovery or failure. Ultimately, this approach will assist the Joint Force in identifying trends that have shaped successful operations in contested airspace.

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[31] Meir Finkel, *On Flexibility: Recovery from Technological and Doctrinal Surprise on the Battlefield* (Stanford, California: Stanford Security Studies, 2011), 2.
[32] Finkel, *On Flexibility*, 2.
[33] Finkel, *On Flexibility*, 2.
[34] Finkel, *On Flexibility*, 2.

As noted earlier, an understanding of the relationship between technology and doctrine is foundational to this analysis. Before examining the historical examples, Chapter 1 examines the importance and limitations of technology and doctrine, as well as well as the nexus between the two. The frameworks that guide this discussion, technological determinism, social construction, and interactive technological systems, will help the Joint Force advantageously manage these complex relationships. In order to navigate the difficult choices required to maintain the ability to operate in contested environments, the armed services must understand the variety of forces that influence the development of technology and doctrine.

Equipped with an understanding of the different types of relationships between technology and doctrine, the next two chapters study the four historical examples mentioned above. Chapter 2 assesses numerous examples of technology and doctrine that played important roles in contested air operations in the skies of Europe during World War II. Examples include the British IADS and its critical role in the Battle of Britain; long-range Allied escort fighters and their impact on the Combined Bomber Offensive (CBO); and the pervasive effects of Germany's offensively oriented doctrine. Chapter 3 examines the Yom Kippur War of 1973 and Operation Mole Cricket 19, Israel's strike on Syrian SAMs in the Bekaa Valley in 1982. Surface-to-air (SAM) technology proved so effective in 1973 that many speculated an end to the ability to project power through the air. Nevertheless, the Israeli Air Force's (IAF) subsequent adaptation and innovation of suppression of enemy air defense (SEAD) techniques and technology proved in 1982 that airpower was still a viable instrument. Ultimately, these examples demonstrate that technology is not a panacea. However, it is clear the combatant who could effectively combine flexible technology and doctrine within the constraints of their nation's grand-strategic context increased its chances of achieving success.

Building on an understanding of technology and doctrine's role in the four historical examples, Chapter 4 synthesizes and compares the trends discovered therein with the current threat environment and the Joint Force's proposed solution for operational access. This comparison will identify areas in which the Joint Force is incurring increased risk, areas that require refinement, and the implications of failing to address these problems.

This study seeks to distill some measure of clarity from complexity in an effort to assist the Joint Force navigate an uncertain, continuously evolving threat environment. Given its limited scope, it is admittedly an incomplete answer; however, it will hopefully provide some small measure of assistance to those among us who strive to ensure a continuous advantage.

Chapter 1

The Technology-Doctrine Nexus

When your weapons are dulled and ardor damped, your strength exhausted, and treasure spent, neighboring rulers will take advantage of your distress to act. And even though you have wise counselors, none will be able to lay good plans for the future.

Sun Tzu

Penetrating an antiaccess/area-denial defense requires an effective system of personnel, technology, organizations, and doctrine. Two of the most significant and malleable components of this system are technology and doctrine. These components are important because technology bounds what is feasible, while doctrine codifies the axioms that guide technology's application and influence its development. To maintain a continuous advantage and develop sufficient flexibility in the face of uncertainty, the Joint Force must manage the nexus of technology and doctrine effectively. Toward this end, the present chapter examines three frameworks that explain the relationships among technology and doctrine. It also offers a methodology with which to identify and assess technological and doctrinal flexibility in the historical examples that follow. Ultimately, this chapter will articulate both the importance and limitations of technology and doctrine, while providing techniques both service leadership and strategists can use to evaluate and develop these important tools.

The Role of Technology in Society, War, and Warfare

Technology includes artifacts or objects, activities and processes, and the knowledge that logically connect an artifact and its process to a desired result.[1] For example, stealth technology consists of more than just aircraft. The concept of stealth consists of artifacts, such as the aircraft; the process of designing, manufacturing, operating, and maintaining those aircraft; and the operational art and tactics of denying an adversary situational awareness. Thus, technology is much more than a piece of advanced equipment, and the whole is more than the sum of its parts. Given both the pace of technological change and the adverse consequences of ineffectiveness in war, effectively harnessing this complex phenomenon is important to the armed forces.[2] Those who would rely on the ability to project power must appreciate technology's importance, as well as its limitations. A closer examination of technology's relationships to society, war, and warfare will shed light on this subject.

Role of Technology in Society

Given that war is a social phenomenon, leaders can clarify the nature of technology's influence through an understanding of the dominant frameworks that describe technology's relationship to society. The debate over this relationship is bounded by two polar interpretations: technology shapes society; or, conversely, society shapes technology.

The first approach, referred to as technological determinism, argues that technologies have the power to drive history.[3] Lynn White's description of the stirrup and its effect on medieval society is an example of this philosophy. The invention of the stirrup ushered in an age of mounted, shock-combat. With the stability of a stirrup, a warrior could land a blow that carried the strength of a horse rather than that of a

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[1] Wiebe E. Bijker, Thomas Parke Hughes, and T. J. Pinch, eds., *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, Anniversary ed (Cambridge, Mass: MIT Press, 2012), xliii.
[2] William Hardy McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000* (Chicago [IL]: University of Chicago Press, 1984), 357.
[3] Merritt Roe Smith and Leo Marx, eds., *Does Technology Drive History?: The Dilemma of Technological Determinism* (Cambridge, Mass: MIT Press, 1994), xiv.

man. As the awareness of this truth spread, the cost of fighting this way expanded. The requirements of paying for specially bred horses, thicker armor, and support personnel eventually resulted in a system of tribute and land ownership recognized today as feudalism.[4] Thus, the stirrup was a small invention that had far-reaching social effects. Of note, Sir Michael Howard argues the relationship between enhanced capabilities and increasing costs remains a feature of contemporary life.[5] One of the most important issues technological determinism examines is the question of whether society's technological choices are expressions of freedom or of necessity.[6]

In contrast to technological determinism, the Social Construction of Technology (SCOT) framework emphasizes the power of choice in shaping technology. This interpretation argues that social groups define the problem, the solution, and the subsequent characteristics of technologies.[7] Social construction can explain the different organizational and doctrinal approaches of the British, German, and American armed forces of WWII. The combination of factors such as diverse cultural norms, geography, historical experiences, political institutions, and resource availability resulted in different doctrines, force structures, and technologies to support each nation's particular needs.[8] In SCOT, as multiple social groups work to solve a problem, multiple approaches to determining a technological solution frequently emerge. The trajectory a technology follows rests firmly with the social groups involved, rather than with technology itself.

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[4] Lynn Townsend White, *Medieval Technology and Social Change* (London; New York: Oxford University Press, 1964), 29.
[5] Michael Howard, *War in European History*, Updated ed (New York, NY: Oxford University Press, 2009), 3.
[6] Smith and Marx, *Does Technology Drive History?*, xiv.
[7] Bijker, Hughes, and Pinch, *The Social Construction of Technological Systems*, 6.
[8] Harold R. Winton and David R. Mets, eds., *The Challenge of Change: Military Institutions and New Realities, 1918-1941*, Studies in War, Society, and the Military (Lincoln: University of Nebraska, 2000), xiii.

Bridging the gap between technological determinism and social construction, historians Thomas Hughes and John Law offer a third perspective based on technological systems and networks. Hughes describes modern technological systems as complex collections of people, artifacts, and ideas.[9] Hughes argues that technological systems follow a loose pattern as they evolve. This pattern indicates that society shapes and is shaped by technology.[10] Hughes also introduces an important temporal influence he terms "momentum." As modern technologies grow in cost and complexity, the number of stakeholders increases. Consequently, as technologies mature, powerful resistance to change frequently develops. In the eyes of Hughes, young technologies tend to be more open to sociocultural influences than mature systems.[11] Navigating this resistance to change requires a skillset that understands the complex network of social, economic, political and scientific forces that contribute to momentum. John Law calls this ability "heterogeneous engineering."[12] Law's heterogeneous engineers recognize the complexity of forces in a network and look for patterns revealed in the collisions between different types of elements. These patterns identify important actors and durable elements that affect the development of a technological system.

Although technological determinism, social-construction, and the evolution of technological systems each provide valuable insights, all three frameworks imperfectly represent reality. There is no single

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[9] Thomas P. Hughes, "The Evolution of Large Technological Systems," in *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, ed. Wiebe E. Bijker, Thomas P. Hughes, and Trevor Pinch (Cambridge, Massachusetts: MIT Press, 2012), 45.

[10] Thomas P. Hughes, "Technological Momentum," in *Does Technology Drive History? The Dillema of Technological Determinism*, ed. Merritt Roe Smith and Leo Marx (Cambridge, Massachusetts: MIT Press, 1994), 102.

[11] Thomas P. Hughes, "Technological Momentum," 101.

[12] John Law, "Technology and Heterogeneous Engineering: The Case of Portuguese Expansion," in *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, ed. Wiebe E. Bijker, Thomas P. Hughes, and Trevor Pinch (Cambridge, Massachusetts: MIT Press, 2012), 106.

answer; strategists must understand the influence that each framework exerts on technological development. For example, technologically deterministic views may warn of unintended consequences or over-estimate the impact a given technology will have on society. Adherents to the social-construction interpretation may over-estimate their control over technology and fail to appreciate technology's effects on society. Malevolent or asymmetric adapters, such as extremists exploiting information technology, are an important influence that can easily be overlooked. Given that it accounts for important aspects of each of the polar frameworks, the technological system and network metaphor offers the Joint Force a practical framework to employ in the development and application of technology. The armed services must fully understand the components of their system, as well as the other systems and forces making up the wider network in which the services act. Identifying the patterns revealed in the collisions between different types of elements in a network is one of the most important parts of this process.[13]

In the search for new technologies, the Joint Force must also accurately identify and exploit the influence of multiple stakeholders. As the services look for effective methods to apply or modify existing technologies, they must recognize the momentum that established technological systems develop. The armed services operate in a complex network of large bureaucracies and a multi-polar security environment that present numerous challenges. Engineering a system that can harness the promise, while respecting the limits, of technology requires the ability to understand and shape the effects of social, political, economic, and technological forces. Leaders versed in the underlying challenge and the dynamics of the relationship between technology and society are equipped with a sound foundation for understanding technology's relationship with war.

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[13] John Law, "Technology and Heterogeneous Engineering: The Case of Portuguese Expansion," 107.

Role of Technology in War

Similar to the varied perspectives on technology's relationship to society, there are multiple perspectives on technology's relationship to war. At the cognitive level, Antoine Bousquet argues different technological paradigms have governed the search for order in war during different eras. The clock represented the ordering and disciplining of troops in "mechanical warfare" during the eighteenth and early nineteenth centuries. The internal combustion engine represented the channeling and projection of energy in "thermodynamic warfare" during the early-to-mid-twentieth century. The computer and information management represented "cybernetic warfare" that was first employed in the Vietnam War. Modern networks represent "chaoplexic warfare," in which contemporary forces exploit concepts such as net-centric operations, simultaneity, and shock.[14] As we shape technology and technology reshapes our management of the environment, changes such as those Bousquet described affect our cognitive approaches to managing the complexity of war.

Martin van Creveld also comments knowledgably on technology's ubiquity in war. Van Creveld contends, "The causes that lead to wars, and the goals for which they are fought; the blow with which campaigns open, and the victories with which they sometimes end . . . not one of these is immune to the impact that technology has had and does have and always will have."[15] The effects of railroads and telegraphs during the nineteenth century support van Creveld's argument. Howard argues these technologies made mass participation in war both possible and necessary.[16] Based on the trends of this period, Howard also argues that the advantage of superior weapons was temporary and unlikely to be

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[14] Antoine J Bousquet, *Scientific Way of Warfare: Order and Chaos on the Battlefields of Modernity.* ([S.l.]: Oxford University Press, 2010), 4.
[15] Martin Van Creveld, *Technology and War: From 2000 B.C. to the Present* (New York : London: Free Press ; Collier Macmillan, 1989), 1.
[16] Howard, *War in European History*, 120.

decisive by itself in economically close-knit societies. There was, however, a point at which the destructiveness of firepower was sufficient to carry the day.[17] In some contexts, technology can decide the outcome of a war.

Some argue that Desert Storm was just such an example. Technological superiority was not only key to the conflict's outcome, but it also shaped perceptions about the nature and character of war. Dolman's description of an "American Way of War" adds an important perspective on how the success of technology in war can affect a nation. Dolman argues the success of technology-spawned tactics utilized in contemporary conflicts has permitted the American liberal consciousness to view war as an increasingly viable tool in international relations.[18] If war is clean and efficient, the nation can avoid many of its ugly consequences.

This observation has two significant implications for national strategy. First, as the armed forces develop strategy in support of national objectives, they must appreciate how technological advantage has shaped a perception of the costs and benefits associated with the use of force. Specifically, the nature of the international environment is such that the use of force is increasingly predicated on the calculation of anticipated casualties, collateral damage, economic disruption, and political responses.[19] This paradigm shapes the role and legitimacy of force in the pursuit of national objectives. Second, the United States must anticipate that its major rivals will not enter into one-sided conflicts.[20] We must appreciate and articulate how adversarial adaptations alter the costs of waging war. Dolman argues that the keys to future combat are "the capacities to evaluate situations accurately, inflict damage precisely, react to enemy counteractions, evaluate

[17] Howard, *War in European History*, 121.
[18] Dolman, *Pure Strategy*, 163.
[19] Dolman, *Pure Strategy*, 163.
[20] Dolman, *Pure Strategy*, 163.

damage, and retarget if necessary . . . the side that does so with the greatest speed and skill is the side that will prevail."[21] A major concern facing US armed forces is the paradigm shift required when the technological advantage that has shaped recent combat successes is no longer readily available.

The challenge of confronting an adaptive adversary is not a new phenomenon. Colin Gray argues that much of the fog and friction that undermines strategy cannot be thwarted by modern technology. Gray warns, "a new device, even in innovative ways to conduct war, is always offered as a poisoned chalice . . . progress in modern strategic performance has not been achieved exclusively through science and technology."[22] Ultimately, an intelligent enemy can compensate for an opponent's technological advantage. Even van Creveld qualifies his earlier point about technology's pervasiveness in war, "Merely because technology plays a very important part in war, it does not follow that it alone can dictate the conduct of war or lead to victory."[23] The ability to combine hardware, training, and doctrine into a coherent whole, effectively tailored for the specific situation or enemy has consistently been one of the most important factors in deciding a war's outcome.[24]

In sum, these arguments make clear that war remains a human endeavor—it is as much influenced by moral factors as it is by physical or technological factors. Technology's effects are but one element that must be melded into the much larger grand-strategic effort. Coordinating and maintaining coherence among these efforts across the various levels of war are some of the most challenging tasks strategists face. As previously noted, technology alone will often not solve this problem of integration. There is, however, an important correlation between technological capacity and a nation's ability to wage war.

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[21] Dolman, *Pure Strategy*, 164.
[22] Colin S. Gray, "Why Strategy Is Difficult," 9.
[23] Van Creveld, *Technology and War*, 6.
[24] Van Creveld, *Technology and War*, 97.

Consequently, technology remains an important tool for strategists, particularly as one shifts the level of analysis from war to warfare.

The Role of Technology in Warfare

In contrast to the human domain of *war*, the air, land, sea, space, and cyber domains of *warfare* are governed by the laws of science. Thus, although science itself is affected by human limitations, technology plays a much more influential role at this level of conflict.[25] History abounds with examples of technologies that produced dramatic effects on the conduct of warfare. In 1346 at Crécy, the numerically inferior English demonstrated the longbow's lethal capability against armored knights on horseback.[26] In 1940, British fighter aircraft guided by information learned from radar demonstrated that the aerial defense could be effective. In 1949, the detonation of Joe-1 prompted serious debate about the character and consequences of future wars between the two super-powers. Clearly, certain technological advances can have significant influence on the character of warfare.

Along these lines, Keith Shimko argues that the reconnaissance-strike complex America employed during Operations Desert Storm and Iraqi Freedom has significantly changed modern warfare.[27] Based on the contrast between air forces of the World Wars and today, this perspective demonstrates the significance that advancing technology holds for projecting power in the air domain. Heavier-than-air flight took centuries to evolve. The air forces of WWI employed aircraft in almost every major role recognized today. The aircraft themselves, however, were technologically immature and had little influence on the outcome of

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[25] Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 3rd ed (Chicago, IL: University of Chicago Press, 1996).

[26] I. B. Holley, *Ideas and Weapons: Exploitation of the Aerial Weapon by the United States during World War I: A Study in the Relationship of Technological Advance, Military Doctrine, and the Development of Weapons*, Special Studies / Office of Air Force History (Washington, D.C: Office of Air Force History : For sale by the Supt. of Docs. U.S. GPO, 1983), 4.

[27] Shimko, *The Iraq Wars and America's Military Revolution.*

the war. These early military aircraft were limited in horsepower, which in turn limited carrying capacity, operating ceilings, and speed. As technology matured, the air forces of WWII were equipped with aircraft that were more capable and able to achieve significant effects at the tactical, operational, and strategic levels of war.

Further evolution through the Korean and Vietnam wars eventually produced the reconnaissance-strike complex employed in Desert Storm. This amalgamation of capabilities enabled single aircraft to accomplish what required large formations to accomplish in WWII. Contemporary fifth-generation aircraft are increasing this effectiveness by denying enemy situational awareness, while exceeding the adversary's performance capabilities. Dolman argues, "With the ability to move into previously controlled enemy air space virtually at will and negate the ability to deny American exploitation of airpower, at a minimum stealth provides areas of air contestability over the whole of the earth."[28] The air weapon's evolution and its effect on warfare highlight technology's importance for projecting power; but as has already been noted, one must also understand this technology's limits.

Van Creveld warns "there is no weapon but that has its limitations and no technology so perfect that it cannot . . . be countered with the aid of the appropriate organization, training, and doctrine."[29] In a similarly pragmatic warning, Stephen Biddle cautions that America's reconnaissance-strike complex has not changed the character of modern warfare. Biddle argues there is a "modern system" of force employment that has existed since WWI. This concept is "a tightly interrelated complex of cover, concealment, dispersion, suppression, small-unit independent maneuver, and combined arms at the tactical level, and depth, reserves and differential concentration at the operational level of

[28] Dolman, *Pure Strategy*, 165.
[29] Van Creveld, *Technology and War*, 230.

war."[30] Biddle argues that the modern system initiated a trend of increasing lethality that remains unchanged today. The increasing range or precision of weapons is simply a change of degree rather than type of lethality.[31] Consequently, in Biddle's estimation, overemphasizing the effects of technology could weaken the American military establishment and undermine its ability to prevail in future combat.[32]

When estimating or evaluating a technology's promise, the Joint Force must appreciate the importance of context. Every conflict is different, and adversaries adapt. A technological advantage may increase a force's efficiency and effectiveness, and the creative application of technology can potentially extend the ends being sought.[33] Strategists must remember, however, that technology is not independently decisive against a skilled, adaptive adversary and advantages are often temporary.[34] Effectiveness is more important than efficiency in war, and such effectiveness may rely on a redundancy and resilience that the latest technological advance is wont to provide.[35] Given the importance of technology in warfare, the evolving nature of technological solutions, and the cost of developing and adopting new technologies, it is important to have sound doctrine that can guide technology's development and application.

The Development of Doctrine in Peace and War

In addition to appreciating technology's importance and limitations, strategists must also grasp those of doctrine. Given the profound nature of its influence and gravity of changing doctrine, strategists must also have useful methods to update doctrine if required.

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[30] Stephen D. Biddle, *Military Power: Explaining Victory and Defeat in Modern Battle* (Princeton, N.J: Princeton University Press, 2004), 3.
[31] Biddle, Hinkle, and Fischerkeller, "Skill and Technology in Modern Warfare," 24.
[32] Biddle, *Military Power*, ix.
[33] Basil Henry Liddell Hart, *Strategy*, 2nd rev. ed (New York, N.Y., U.S.A: Meridian, 1991), 323.
[34] Van Creveld, *Technology and War*.
[35] Van Creveld, *Technology and War*, 317.

Importance of Doctrine

At the grand-strategic level, Barry Posen asserts that doctrine guides the types of military means employed, as well as their use. At this level, doctrine generates a set of prescriptions specifying how military forces should be structured and employed in response to threats.[36] State doctrine affects the quality of international life by influencing the type and frequency of armed conflict. The offensive, defensive, or deterrent character of doctrine also affects the probability and intensity of arms races.[37] The level of agreement between political ends and military means fundamentally affects the security of the state itself. Military doctrine should be smoothly integrated into political objectives. These objectives guide the development of tools suitable for the pursuit of national objectives.

In his study on the role of doctrine at the service level, I.B. Holley offers the idea that doctrine defines the roles and missions of the service and accordingly guides which weapons should be developed. Doctrine also provides a schema for prioritizing among competing roles or weapons systems.[38] A service with a robust, clearly articulated doctrine can successfully steward its forces through difficult challenges in peace and war.

Dolman highlights the value of doctrine at the operational and tactical levels in enhancing efficiency and preserving time, "Doctrine assists tactical and operational decision makers into making optimum selections in a given, though generic, circumstance."[39] To save time, decisions can be made in advance. The decision maker simply has to recognize the context of a situation and follow the established rules or

[36] Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany between the World Wars* (Ithaca: Cornell University Press, 1984), 13.
[37] Posen, *The Sources of Military Doctrine*, 15.
[38] Holley, *Ideas and Weapons*, v.
[39] Dolman, *Pure Strategy*, 44.

doctrine associated with it. Doctrine fails, however, when it is surprised.[40]

Limitations of Doctrine

Such surprise may stem from a failure to appreciate the importance of context. Posen notes that if doctrine fails to respond to changes in political circumstances, adversary capabilities, military technology, or is insufficiently innovative for a commander, a state faces probable defeat.[41] In order to retain its value, doctrine must minimize restrictions and remain flexible. As Dolman notes, there is a delicate balance and scaled approach to maintaining doctrine: "Doctrine is not invalidated simply because it is not used. It is invalidated when it no longer makes sense for normal operations."[42] A leader may make a choice to diverge from doctrine. If the choice is valid for the specific instance, doctrine may be adjusted. If the choice is found to be superior to doctrine in all circumstances, doctrine should be rewritten.[43]

Development of Doctrine in Peacetime

During peacetime, two of the largest constraints to refining doctrine are fiscal limitations and organizational resistance to change. After his 1973 lecture "Military Science in an Age of Peace," Sir Michael Howard was asked how the armed services could effectively plan in an environment of periodic changes in national aims. He answered that fiscal capability and certain constant factors devolving from a nation's geopolitical position must guide national policy and military doctrine. A pragmatic understanding of the nation's political, economic, and security interests will inform the problems the military may likely be called upon to solve.[44] Such grand-strategic requirements guide the development of both military strategy and doctrine.

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[40] Dolman, *Pure Strategy*, 153.
[41] Posen, *The Sources of Military Doctrine*.
[42] Dolman, *Pure Strategy*, 162.
[43] Dolman, *Pure Strategy*, 162.
[44] Howard, "Military Science in an Age of Peace," 10.

In response to the perpetual uncertainty that accompanies this type of discussion in a democracy, Dolman argues that armed services are better served by refining existing doctrine than changing it too frequently. Doctrine's stability is important, but it must be tested and challenged in peacetime. The optimal way to refine doctrine is to generate decision scenarios, develop options, and evaluate potential outcomes to form alternative approaches. As these alternatives gain sustained legitimacy, they become an effective route toward changing doctrine prudently.[45]

Given the hierarchical nature of military organizations and their traditional resistance to change, senior officer involvement is critical to the success of such reform efforts. Stephen Rosen argues that peacetime military innovation may be explained by how military services evaluate the character of future wars and how they effect change in the senior officer corps.[46] "Peacetime innovation has been possible when senior military officers with traditional credentials reacting . . . to a structural change in the security environment have acted to create a new promotion pathway for junior officers practicing a new way of war."[47] This pattern shifts significantly once the armed services confront the requirement to innovate during war.

Development of Doctrine in War

Rosen argues that military innovation is required in war when inappropriate strategic goals are being pursued or the relationship between military operations and strategic goals has been misunderstood.[48] This problem is exacerbated because decision makers at the operational and tactical levels are limited in time and consequently

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[45] Dolman, *Pure Strategy*, 44.
[46] Stephen Peter Rosen, *Winning the next War: Innovation and the Modern Military* (Ithaca: Cornell University Press, 1991), 52.
[47] Rosen, *Winning the next War*, 251.
[48] Rosen, *Winning the next War*, 35.

constrained in choice.[49] Rosen argues the key to addressing these challenges successfully has been defining new measures of strategic effectiveness, ensuring effective intelligence collection, and creating an organization able to implement the change within the war's remaining duration.[50] Critical steps that contribute to this capability are developing flexible technology and doctrine and effectively managing their nexus.

The Nexus of Technology and Doctrine

The above analysis has examined technology and doctrine's importance and limits. We must now consider the relationship between the things themselves. Successfully managing this nexus amidst challenges from adaptive adversaries in an environment of pervasive uncertainty is one of the greatest challenges the armed services may face. As the Joint Force searches for an appropriate methodology to develop and manage this relationship, the three frameworks that opened the chapter will also illuminate different types of technological-doctrinal relationships.

Technological Push

This relationship between technology and doctrine is derived from the technologically deterministic view of history. The atomic weapon is one of the most prominent examples of a technological push for doctrine. While the Manhattan Project intended to produce a weapon of fearsome proportions, national leaders did not fully understand the dramatic effect this instrument would have on future wars. Nuclear weapons not only prompted a lengthy debate over optimal strategies for their use, they also reshaped the idea of limited war. Alan Stephens notes that the Korean War, fought in the shadow of Hiroshima and Nagasaki, introduced the idea of deterrence *in* war. Superpowers would still engage each other with military force, but the desire to avoid nuclear war noticeably restrained the conflict. The US and USSR would engage indirectly

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[49] Dolman, *Pure Strategy*, 153.
[50] Rosen, *Winning the next War*, 52.

through proxies and observe self-imposed limits, such as the exclusion of certain weapons, a ceiling on the level of force applied, and strict observance of geographic boundaries.[51] Although atomic weapons were consciously sought, their effects and the required changes to strategy and doctrine were determined significantly more by the nature of the technology rather than by forethought.

Lynn White argues that new devices merely open a door but do not compel one to enter, "The acceptance or rejection of an invention, or the extent to which its implications are realized if it is accepted, depends quite as much upon the condition of a society, and upon the imagination of its leaders, as upon the nature of the technological item itself."[52] Previous analysis has established that technology plays a fundamental role in achieving success in the air domain. As the Joint Force continues to advocate for and develop technology, the armed services must remain aware of technological pushes. Initially a new technology may seem to be anathema to established doctrine. The key is to investigate it closely in order to determine whether it will require wholesale shifts in doctrinal thinking or merely minor adjustments.

Doctrinal Pull

Occasionally, doctrine may pull or generate requirements for new technology. William McNeill and Martin van Creveld both describe a concept termed "invention of invention" that conveys the context and mindset that opened the door to this type of approach. By the mid-nineteenth century, the pace of technological invention went from being accidental or exceptional to purposeful.[53] The significance of this development was that from this point forward, basing one's calculations on existing hardware or techniques potentially invited defeat.

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[51] Alan Stephens, "The Air War in Korea, 1950-1953," in *A History of Air Warfare*, ed. John Andreas Olsen (Washington, D.C: Potomac Books, 2010), 87.
[52] White, *Medieval Technology and Social Change*, 28.
[53] Van Creveld, *Technology and War*, 218; McNeill, *The Pursuit of Power*, 357.

When either doctrine or requirements lead directly to implementing technologies, social construction frames the relationship. One example of this type of relationship was the American and British development of long-range bombers before and during WWII. Both nations benefitted from natural strategic defenses, and in the aftermath of WWI it was clear that maintaining and deploying a large army to the European Continent was undesirable. Advocates such as Brigadier General William "Billy" Mitchell and Air Marshal Hugh Trenchard theorized that strategic bombing could affect an enemy and potentially negate the requirement for armies to conduct major combat operations. The primary issue was that the aircraft technology of WWI and the interwar years was not yet capable of achieving the reach and payloads that would be required to support this doctrine. Theory shaped the development of four-engine bombers like the B-17, B-24, B-29, and Avro Lancaster, which could fly higher and carry heavier payloads than previous bombers, was due largely to the doctrinal requirements for long-range bombers developed by the RAF and the US Army Air Forces.

These efforts relied on forward-thinking organizations such as the US Army Air Corps Tactical School and visionary leadership from individuals such as General Henry "Hap" Arnold and Air Marshal Hugh Trenchard. Visionary leadership that can reduce ambiguity by articulating an accurate picture of the probable future is an important ingredient in socially constructing a solution to a technological problem. As noted earlier, preparing in an environment of uncertainty yields no easy answers. In such circumstances, leaders responsible for planning for an uncertain future should apply Howard's advice regarding the development of consensus in identifying the problems the nation faces. Establishing a clear understanding of the nation's likely challenges is a necessary step in establishing sound doctrine that can guide the development of technology in the service of grand strategy.

Interactive Process

One of the most common relationships between technology and doctrine is an interactive process that is similar to Hughes's concept of technological systems and their associated momentum. Hughes argues that shaping technological development is easiest before a system has acquired political, economic, and cultural value components.[54] This assertion does not deny established systems the capacity to change, but it highlights the level of effort or shifts in context that can drive such a change.

The transition of the USAF's reconnaissance-strike complex from Colonel John Warden's Instant Thunder campaign to its subsequent incorporation into service doctrine is an example of such an interactive process. John Andreas Olsen notes that while planning for Desert Storm, General Schwarzkopf was interested in an *air option*, but Col Warden was offering an air-centric *military solution*.[55] The foundation of this plan was a belief that precision weapons and stealth technology made it possible to achieve maneuver, mass, and concentration on an unprecedented scale.[56] The fact that Col Warden's plan discounted the threat posed by Iraqi tanks deployed along the Kuwaiti-Saudi border and challenged the momentum of AirLand Battle doctrine presented significant obstacles to its complete implementation.

In other circumstances, Col Warden's unitary air campaign might not have lived past the concept stage, but risk was an important consideration for General Schwarzkopf. With noteworthy modifications, Col Warden's plan offered an opportunity to reduce the risk to Coalition forces significantly. This factor ultimately gave the air campaign sufficient force to overcome the momentum of those against the plan. Although changes were made to the original Instant Thunder plan, the major themes of the proposal were ultimately incorporated into the

[54] Thomas P. Hughes, "Technological Momentum," 112.
[55] John Andreas Olsen, *John Warden and the Renaissance of American Air Power*, 1st ed (Washington, D.C: Potomac Books, 2007), 159.
[56] Olsen, *John Warden and the Renaissance of American Air Power*, 241.

Desert Storm campaign with profound success. Today, practitioners recognize concepts such as the IADS rollback, strategic paralysis, and systemic effects as being viable concepts in airpower's doctrinal arsenal.

Factors beyond technological determinism or social construction influenced this course of events. AirLand Battle doctrine had momentum. It was the Joint Force's solution for conventional combat against the numerically superior Soviet threat. As preparations for Desert Storm advanced, an optimal combination of new technology, a unique idea, and an environment friendly to innovation produced a significant evolution in airpower doctrine. The Joint Force must keep momentum in mind as the services develop both technology and doctrine. Identifying the source and power of such momentum includes an honest look at forces within the armed services, as well as among the network of other forces throughout government and commercial organizations. Developing the ability to employ or overcome momentum when required is an important skillset for managing an interactive technological-doctrinal relationship.

Maintaining Technological and Doctrinal Flexibility

One of the most important aspects of managing the various technological-doctrinal relationships is maintaining flexibility. As noted in the introduction, Howard argued that there was one "aspect of military science which needs to be studied above all others in the Armed Forces: the capacity to adapt oneself to the utterly unpredictable, the entirely unknown."[57] Given the ever-present challenges of fog, friction, and an intelligent, adaptive adversary, Meir Finkel argues that the solution to technological and doctrinal surprise centers on a force's ability to recover.[58] This ability is significantly shaped by a force's flexibility across multiple categories. Finkel categorizes flexibility into four strata. The first level is conceptual and doctrinal. This centers on an environment

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[57] Howard, "Military Science in an Age of Peace," 7.
[58] Finkel, *On Flexibility*, 2.

that encourages ideas that may challenge official doctrine, as well as one that embraces a balanced view of all forms of war.[59] The second level is organizational and technological. Optimal characteristics in this level are a balance among military capabilities, organizational diversity, redundancy, and technological versatility.[60] The third level includes flexibility in command and cognitive skills. This includes mental flexibility, creativity, and flexible command similar to *auftragstaktik* or the idea of "mission command."[61] The fourth level is the ability to learn and rapidly disseminate lessons learned.[62] Ultimately, forces that prioritize and demonstrate flexibility across these levels are better equipped to overcome the surprise inherent in armed conflict.

Assessing Flexibility

In order to identify successful historical trends for contemporary application, this study employs Finkel's framework for assessing flexibility. This process defines the nature of the surprise, assesses the level of recovery, and identifies the elements of flexibility that led to the result. The following scale estimates the effectiveness of a force's recovery: the best solution results in complete recovery and generates a new problem for the enemy; the second level neutralizes the problem, but fails to challenge the enemy with a new problem; the third level minimizes the amount of damage from the surprise; and the fourth level is a failure to recover from surprise.[63] Awareness of Finkel's construct for assessing flexibility and identifying successful examples should help the armed services identify and carry forward successful trends that can guide the development of technology and doctrine for contested operations.

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59 Finkel, *On Flexibility*, 2–3.
60 Finkel, *On Flexibility*, 3.
61 Finkel, *On Flexibility*, 4; General Martin E. Dempsey, "Mission Command," April 3, 2012, http://www.dtic.mil/doctrine/concepts/white_papers/cjcs_wp_missioncommand.pdf.
62 Finkel, *On Flexibility*, 4.
63 Finkel, *On Flexibility*, 8–9.

Summary

The Joint Force relies on both superior tools and innovative ideas for its deterrent and war-winning capabilities. Efficiently developing such tools and ideas with sufficient flexibility to maintain a continuous advantage is no small task. In an environment of pervasive uncertainty and limited resources this requires the ability to discriminate between enduring historical trends and anomalies of the present, in the light of the probable future. As there is no dominant framework for understanding technology's relationship to society, the Joint Force must be conversant with and able to navigate among three distinct philosophies that explain the relationship: technological determinism, social construction, and technological systems. Though it is often fundamental to successful operations in contested domains, technology must not be thought to be a panacea. The differences between the human domain of war and physical domains of warfare must be kept in mind throughout this process. We must not forget the effects generated in the physical domains are but a subset of grand-strategic efforts to secure a better and lasting peace.[64]

An understanding of historical trends is a critical aspect of requirements-based arguments for new technology. These requirements must be generated and sustained by robust, flexible doctrine. Whether through a technological push, doctrinal pull, or an interactive relationship, the development of Joint Force doctrine and technology must remain sufficiently flexible to adapt and respond to new advances. Equipped with an understanding of the importance of technology and doctrine and a method to evaluate their effectiveness, the next two chapters identify trends of four historical contested air operations: the Battle of Britain, the Combined Bomber Offensive, the Yom Kippur War, and Operation Mole Cricket 19. The hope here is, as William McNeill

[64] Liddell Hart, *Strategy*, 322.

stated, "…analyzing changes in older balances between technology, armed force, and society will not solve contemporary dilemmas. It may, nonetheless, provide perspective and, as is wont of historical awareness, make simple solutions and radical despair both seem less compelling."[65]

[65] McNeill, *The Pursuit of Power*, viii.

Chapter 2

The Battles for the Skies of Europe

> *If there is one thing more certain in war, it is that we shall have to improvise and operate under conditions very different from those prevailing in peace.*
>
> Sir John Slessor

As previously noted, the challenge of contested skies is not unique to this generation. The Battle of Britain and the Combined Bomber Offensive are examples of some of the fiercest and closely matched aerial combat in history. Examining how each belligerent navigated the surprise inherent in war will add substance to the relationships discussed in the previous chapter.

This study begins the examination of each conflict with a brief description of both the context that shaped each belligerent's doctrine and force structure, as well as a brief chronological description of significant turning points during the battles. The subsequent investigation determines the type of surprise each belligerent faced, examines what factors led to recovery or failure, and describes the type of technological-doctrinal relationship that characterized these efforts. Ultimately this analysis identifies influential technologies, doctrines, and adaptations that had significant influence on each campaign's outcome.

In the case of the Battle of Britain, the British won the campaign for which they had prepared, while the Germans failed to develop sufficient strategic or operational flexibility to recover from surprise. The Allies were able to prevail in the CBO due to their ability to sustain mass, while adapting their efforts over time. The German defense, on the other hand, failed based on early decisions that prioritized offensive airpower over requirements to build an effective air defense. Although foresight played a critical role in each of these contests, neither of these outcomes was a foregone conclusion. It is clear, however, that the combatant that developed sound technology and doctrine, appropriately balanced with the nation's strategic context, while remaining flexible in both planning and execution, noticeably increased its chances of achieving success.

The Battle of Britain

Numerous stimuli shape a nation's doctrine. In the case of Britain and Germany, WWI was a key influence in the development of doctrine and force structure. The British sought to avoid repeating the tragedy of WWI and prepared to minimize participation in future land conflicts on the European Continent.[1] Consequently, by the mid-1930s, British military strategy centered on securing the homeland with effective naval and air defenses, while letting its continental neighbors pay the major price of any future war in Europe.

Due to their location in the heart of the continent and Hitler's grand designs on *lebensraum* to the east, the Germans had no such luxury. They had also learned from the punishing costs of WWI; but rather than retrenching, the Third Reich pursued an expansionist policy with an acquisitive military strategy and an offensive doctrine. Barry Posen observes that Germany "directed her industrial and military resources toward fighting short, decisive wars of aggression against those immediate neighbors who had most profited from her 1918 defeat, and who would most oppose a resurgence of military power."[2] The result was a German military strategy that developed a strong, combined-arms force designed for rapid conquest of continental adversaries.

Campaign Narrative

[1] Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany between the World Wars* (Ithaca: Cornell University Press, 1984), 82.
[2] Posen, *The Sources of Military Doctrine*, 82.

When France surrendered in June 1940, Britain was the last major obstacle to Germany's west that could interfere with Hitler's plans to the east. As it became clear the British would not surrender under Prime Minister Winston Churchill's leadership, Hitler was confronted with a choice between a long siege or quick decision through an invasion.[3] Based on the German strategic timeline and a desire to avoid a two-front war with Britain and Russia, the latter being the next German target, Hitler chose an invasion. The prerequisite for the invasion was to gain air superiority in order to minimize the RAF's ability to interfere with German forces crossing the Channel. Of note, the Luftwaffe would have to accomplish this task before winter weather effectively closed the Channel to invasion forces.

The Battle of Britain began in mid-July 1940 with German attacks on English shipping in the Channel and coastal defenses. The Luftwaffe's first intention was to probe British defenses, but through June and July 1940 attacks intensified to close the Channel to British shipping.[4] By mid-August, Luftwaffe Commander-in-Chief Hermann Göring initiated Operation Eagle and shifted the focus of the offensive toward destruction of the RAF. Eagle was designed to destroy the RAF through large battles in the air, as well as attacks on British airfields and radar stations.[5] On 4 September 1940, frustrated by poor weather and Fighter Command's ability to generate large numbers of defensive fighters on a daily basis, the German leaders shifted the offensive's focus to London and other major cities.[6] Hitler gave the Luftwaffe five weeks to create the conditions for victory, so as time ran short German leaders chose to attack the British population in the hopes this would force

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[3] Stephen Bungay, *The Most Dangerous Enemy: An Illustrated History of the Battle of Britain* (Minneapolis: Zenith Press, 2010), 26.
[4] Bungay, *The Most Dangerous Enemy*, 104.
[5] "BBC - History - The Battle of Britain (pictures, Video, Facts & News)," accessed April 15, 2014, http://www.bbc.co.uk/history/battle_of_britain.
[6] "BBC - History - The Battle of Britain (pictures, Video, Facts & News)."

capitulation.[7] On 17 September, Hitler issued an order postponing the invasion indefinitely.[8] Although fighting in the air continued through the remainder of September and October, most historians argue the Battle of Britain concluded by 31 October 1940.[9]

The Royal Air Force in Defense of Britain

Although the RAF faced many challenges during the Battle of Britain, one of its most important adaptations occurred before the battle began. The following analysis examines the inter-war doctrinal surprise British leaders confronted and their subsequent efforts to recover through doctrinal and technological flexibility. These efforts are then compared to the interactive-systems metaphor of a technological-doctrinal relationship described in the previous chapter.

Surprise. During the inter-war years, the RAF promoted strategic-bombing as the optimal means with which to deter and, if necessary, punish an air attacker.[10] As war with Germany began to appear imminent during the late 1930s, RAF leaders confronted real-world limitations. The British had limited ability to produce sufficient numbers of long-range bombers. Tami Davis Biddle notes, ". . . Harris and the air planners of 1936 were forced to start closing the gap between rhetoric and reality; they had to think concretely about scenarios based on resources available in the near term."[11]

Recovery. As the results of the Battle of Britain attest, the British not only recovered from the unanticipated limitations of strategic-bombing, the development of a functional IADS created a new problem for the Luftwaffe. Demonstrating conceptual and doctrinal flexibility, the British eventually adopted Sir Thomas Inskip's argument that having

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[7] Bungay, *The Most Dangerous Enemy*, 85.
[8] Bungay, *The Most Dangerous Enemy*, 227.
[9] Bungay, *The Most Dangerous Enemy*, 234.
[10] Posen, *The Sources of Military Doctrine*.
[11] Tami Davis Biddle, *Rhetoric and Reality in Air Warfare: The Evolution of British and American Ideas about Strategic Bombing, 1914-1945* (Princeton, N.J.: Princeton University Press, 2002), 115.

fighter aircraft destroy German bombers over Britain would be more effective than attacking German factories and aerodromes with bombers.[12] Fighters alone, however, would have been insufficient without the organizational and technological flexibility to develop and direct a complex, centralized national air defense. The man responsible for this task was Air Marshal Sir Hugh Dowding, who constructed an IADS with Fighter Command as the central command-and-control entity.

The Dowding System divided airspace responsibility into four Groups, each supported by multiple Sectors, which, in turn, controlled up to six fighter squadrons. In addition to the communications infrastructure that linked these organizations, the network of early-warning Chain Home radars and ground-based Royal Observer Corps were the most critical components of Dowding's system. The Chain Home and Chain Home Low radars gave the British valuable early-warning indicating the size and direction of incoming threats well before they reached the English coast. The Observer Corps tracked aircraft visually after they made landfall and provided important intelligence on low-flying aircraft that could evade the radar network.[13] The information gained from this network increased Fighter Command's situational awareness, survivability, and lethality.[14]

With sound situational awareness, the bulk of British fighters could stay on the ground, be maintained, and rest rather than be constantly patrolling. This efficiency was crucial because the Luftwaffe's front-line fighters, Bf 109s outnumbered RAF Hurricanes and Spitfires by a ratio of at least 1.5:1.[15] Equipped with clear situational awareness, Fighter Command could also ensure its survivability by choosing the optimal times at, places where, and strengths with which to intercept German

[12] Biddle, *Rhetoric and Reality in Air Warfare*, 121.
[13] Bungay, *The Most Dangerous Enemy*, 47.
[14] Paul M. Kennedy, *Engineers of Victory: The Problem Solvers Who Turned the Tide in the Second World War*, 1st ed (New York: Random House, 2013), 93.
[15] Bungay, *The Most Dangerous Enemy*, 77.

attacks. With the ability to intercept the enemy well before a raid reached inland targets, Air Marshal Hugh Dowding and Air Vice Marshal Keith Park emphasized smaller, squadron-sized intercepts over Air Vice Marshal Trafford Leigh-Mallory's "Big Wing" concept.[16] Although Luftwaffe escorts often outnumbered RAF fighters during an attack, launching single-squadron formations saved valuable intercept time. It also minimized the amount of aircraft lost if the Luftwaffe were able to attack a scramble in mid-launch.

In addition to the survivability that situational awareness and squadron-sized intercepts afforded, these smaller formations also increased RAF lethality. As British fighters closed with their adversaries, the smaller formations were more difficult to detect visually. Fewer friendly aircraft also made command of the visual engagement manageable. Consequently, RAF pilots could devote significant attention to their German targets. Additionally, with the time saved in the launch, Fighter Command could intercept the bombers quickly and inflict significant casualties with successive attacks.[17]

The straightforward, but perhaps counterintuitive, approach of using squadron-sized attacks also highlights the RAF's cognitive flexibility. Throughout the battle, the Luftwaffe imposed heavy costs on Britain. Rather than emphasizing the prevention of these attacks at any cost, Dowding focused on Fighter Command's survival. He recognized that as long as Fighter Command remained a "force in being," the Germans could not and therefore would not achieve air superiority.

Technological-Doctrinal Relationship. The relationships among the British government, the RAF, and the RAF's doctrine constitute an example of an effective interactive system. Although the British had pursued strategic-bombardment as their primary air strategy until it became materially infeasible, they also made the important decision to

[16] Bungay, *The Most Dangerous Enemy*, 94.
[17] Bungay, *The Most Dangerous Enemy*, 257.

hedge their bets by continuing to invest in air defense and Fighter Command.[18] The critical decision made in the late 1930s to switch from bomber production to fighter production and the flexibility demonstrated during the summer of 1940 were fundamental to the British victory.

Summary Insights. The courage and sacrifice of "the few" played an undisputable role in the battle's outcome, but we must not forget the important lesson that Britain won the battle for which it had prepared. During the inter-war years, the British were confronted with a doctrinal surprise based on material limitations. Recovery from this surprise required both doctrinal and technological flexibility. Doctrinally, the RAF shifted the focus of its air efforts from strategic-bombing to fighter-based defenses. This shift in focus also required technological flexibility to enhance the existing air defense network and pursue new technologies such as radar that provided critical early warning and situational awareness. Effectively managing the technological-doctrinal relationship and successfully defending England was no small task. Colin Gray notes, "The RAF chose the strategy that was correct for its total strategic context and feasible with the material and human means available to it and executed it consistently and competently at all necessary levels of performance."[19] The Luftwaffe, in contrast, was far less successful.

The Luftwaffe in the Battle of Britain

The following analysis examines the Luftwaffe's surprise at its failure to achieve air superiority during the summer of 1940, the lack of doctrinal and cognitive flexibility that contributed to its defeat, and the doctrinal momentum that inhibited the development of sufficient flexibility to recover from surprise.

Surprise. After its spectacular achievements in Poland, Denmark, Norway, Holland, Belgium, and France, the Luftwaffe was surprised by

[18] Posen, *The Sources of Military Doctrine*, 103.
[19] Colin S. Gray, *Airpower for Strategic Effect* (Maxwell Air Force Base, Ala: Air University Press, Air Force Research Institute, 2012), 121.

its inability to achieve air superiority over southeastern England during the summer of 1940.[20] This is not to say the Luftwaffe underestimated the RAF. The major issue at hand presented a paradox. As Stephen Bungay notes, the Germans "needed a high kill ratio, which meant selecting only favorable opportunities, but they also needed a high absolute level of kills, which meant using every opportunity for fighting."[21] This was to prove quite difficult as radar gave the British an operational advantage in selecting the parameters of the individual engagements. The Dowding system provided effective early warning and situational awareness, which, in turn, afforded Fighter Command the ability to avoid the decisive engagements the Luftwaffe was seeking, while implementing a cumulative approach that over time inflicted significant casualties and denied victory to the adversary. The Luftwaffe misunderstood the Dowding System's technology and doctrine. To prevail while maintaining sufficient strength to cover the channel crossing, the Luftwaffe required a kill ratio of 2:1; but in the end, it was the RAF that achieved a 1.8:1 kill ratio.[22] Although the Luftwaffe was able to impose a terrible price, the Germans were unable to recover from technological and doctrinal surprise within the conflict's limited time, and they ultimately lost the campaign.

Failure to Recover. Part of this failure was a result of the doctrine guiding Luftwaffe employment. As previously noted, Germany developed an armed force to achieve its objectives on the European Continent. When the Luftwaffe and Wehrmacht worked together, the results were impressive; however, this operational construct had its limitations. Proficiency in combined-arms operations came at the expense of the ability to conduct effective independent air operations. Bungay notes "Eagle, barely a 'plan' at all, amounted to little more than

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[20] Bungay, *The Most Dangerous Enemy*, 40.
[21] Bungay, *The Most Dangerous Enemy*, 247.
[22] Bungay, *The Most Dangerous Enemy*, 247.

flying over England, dropping bombs on various things, and shooting down any fighters which came up as a result."[23] Haphazardly organized air attacks stood little chance of achieving strategic effects against Britain's centrally coordinated defense. Williamson Murray notes, "With a commander in chief far removed from the battle, with its air fleet commanders ensconced in comfortable mansions, the Luftwaffe moved from one strategic conception to another with no clear idea of an overall strategy. Blinded by its own intelligence as to the importance of the radar system…the Luftwaffe was still capable of inflicting excruciating pain on Fighter Command. But that pain, without the discipline of a strategic concept, could not gain a decisive victory."[24]

At the cognitive level, Luftwaffe leaders and planners understood neither the nature of the targets nor the British aircraft industry's output. Exacerbating the issue, the German fleets were spread out between Denmark, Brittany, and Norway; and each was independently responsible for selecting its targets. This geographic dispersion and command structure limited the Luftwaffe's ability to generate creative solutions to the dilemma posed by British early-warning capabilities. Although challenging, the task was feasible. Arguing this point, Stephen Bungay maintains that the Luftwaffe was sufficiently well equipped to combat the RAF in the Battle of Britain. Bungay suggests that the optimal approach would have been to target the early-warning system, followed by command and control, and finally, RAF aircraft and pilots.[25] To prevail, the Luftwaffe had to narrow Britain's technological edge; but it lacked the situational awareness, as well as doctrinal and cognitive flexibility, to do so.

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[23] Bungay, *The Most Dangerous Enemy*, 88.
[24] Williamson Murray, "The Luftwaffe Against Poland and the West," in *Case Studies in the Achievement of Air Superiority*, ed. Benjamin Franklin Cooling (Washington, D.C: Center for Air Force History, 1994), 101.
[25] Bungay, *The Most Dangerous Enemy*, 250.

Technological-Doctrinal Relationship. Despite being well equipped, the Luftwaffe was unsuccessful in the Battle of Britain.[26] The dominant issue was that British geography, force structure, and doctrine made Britain a much different adversary that either Poland or France. Murray argues that the German air leaders were surprised because, "…the strategic framework of the Battle of Britain was so radically different from their experience that they never properly grasped the issues."[27] Along similar lines, Paul Kennedy wryly observes, "During the long, hot summer of 1940, over the wheat fields and orchards of Kent and Sussex, strategic theory encountered logistical and organizational reality."[28] During early campaigns of 1939-1940, Luftwaffe had operated within favorable range, in concert with the army, and against no serious opposition in the air.[29]

The Luftwaffe's operational force structure and doctrine were largely shaped by the pull of Germany's strategic doctrine. This relationship served Germany well for the first few years of the war, but these successes created a doctrinal-technological momentum that was ill-suited to the future. Critical changes in context occurred when German objectives shifted to achieving air superiority in support of a potential cross-Channel invasion. German leaders failed to recognize these changes, and without sufficient doctrinal and cognitive flexibility to overcome the system's momentum, they failed to adapt and achieve their objectives in the limited time available.

Summary Insights. During the summer of 1940, the Luftwaffe was surprised by its failure to achieve air superiority. German leaders struggled to adapt, but had insufficient doctrinal or cognitive flexibility to organize an effective air offensive. The momentum of successful combined-arms operations and the air offensive's limited time frame

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26 Williamson Murray, "The Luftwaffe Against Poland and the West," 101.
27 Williamson Murray, "The Luftwaffe Against Poland and the West," 103.
28 Kennedy, *Engineers of Victory*, 89.
29 Kennedy, *Engineers of Victory*, 87.

ultimately prevented the Luftwaffe from achieving its objectives. Doctrinal momentum would continue to plague the Luftwaffe as a major portion of its efforts shifted to the defense of Germany.

The Combined Bomber Offensive

British and American airmen started the search for an effective method to wage war before the close of WWI. Given the vulnerability of targets to air attack, it followed that an air campaign directed at the enemy's vital centers could potentially obviate the need for a ground offensive and directly bring about an adversary's capitulation.[30] Although the effects of a strategic air campaign were unproven, a long-range bombing offensive became an important strategic narrative for the Allies in World War II. For Prime Minister Churchill, it argued that Britain could still be an active participant in the war, even after having been forced off the Continent in June 1940. For President Roosevelt, it helped demonstrate that the European theater was a priority even if a ground offensive could not immediately be initiated. Forcing Germany to attend to its air defenses also provided some level of relief for Stalin who had persistently engaged his Western counterparts to open a second front.[31] Thus, the Allied strategic-bombing offensive had clear strategic import. Its first three years, however, were plagued with problems and failed to match expectations.[32]

The German air defense that confronted the Allied strategic-bombing efforts was shaped by the same factors that had shaped the Luftwaffe's offensive approach to air warfare. In addition to a belief in the strength of offensive action for gaining air superiority, technological immaturity and a pragmatic assessment of the challenges of a long-range

[30] Richard Overy, "The Air War in Europe, 1939-1945," in *A History of Air Warfare*, ed. John Andreas Olsen (Washington, D.C: Potomac Books, Inc, 2010), 28.
[31] Richard Overy, "The Air War in Europe, 1939-1945," 45.
[32] Richard Overy, "The Air War in Europe, 1939-1945," 45.

air offensive also guided the Luftwaffe's defensive efforts.[33] Donald Caldwell and Richard Muller note, "Given the limited performance of aircraft and their radios, it is not surprising that German air-defense concepts and tactics in the 1930s tended to emphasize point-defense…rather than a centrally controlled air defense capable of massing interceptors from some distance from incoming bomber formations."[34] Additionally, the Germans recognized that navigating and accurately striking targets from the air, particularly in bad weather or at night, was extremely challenging. Given the challenges of a long-range air campaign, German military leaders believed early on that observation and flak would be sufficient to disrupt an adversary's offensive air effort.[35] This approach proved adequate against the early, limited-strength Allied bombing efforts; but as the war progressed, it became progressively less effective.

Campaign Narrative

The Allies initially adopted a strategy of strategic-bombardment for the Western Front based on the challenge of launching a major ground offensive on the European Continent.[36] Richard Overy argues that during the first three years of the bombing offensive, there was a wide gap between expectations and reality.[37] The Butt Report of August 1941 noted that given the challenges of penetrating German airspace, only one-third of Bomber Command aircraft came within five miles of the assigned targets.[38] Early losses made daylight bombing impractical, so the RAF resorted to night attacks and area bombing. When Air Marshal Arthur Harris took over Bomber Command in February 1942, a new

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[33] Donald L Caldwell and Richard Muller, *The Luftwaffe over Germany: Defense of the Reich* (London; St Paul: Greenhill ; MBI Publishing, 2007), 16.
[34] Caldwell and Muller, *The Luftwaffe over Germany*, 25.
[35] Richard Overy, "World War II: The Bombing of Germany," in *The War in the Air, 1914-1994*, ed. Alan Stephens, American ed (Maxwell Air Force Base, Ala: Air University Press, 2001), 119–120.
[36] Richard Overy, "The Air War in Europe, 1939-1945," 40.
[37] Richard Overy, "The Air War in Europe, 1939-1945," 46.
[38] Richard Overy, "The Air War in Europe, 1939-1945," 46.

directive identified the morale of the German people and industrial workers as Bomber Command's primary target. A few months later, American strategic-bombing forces entered the offensive. Eighth Air Force's operational approach was influenced by the US Army Air Corps Tactical School's Air War Plans Division Plan 1 (AWPD-1) and relied on high-altitude daylight precision bombing of select industrial targets. Allied leaders joined these two different operational approaches in articulating what became known as the Combined Bomber Offensive (CBO) at Casablanca in January 1943.

Without long-range fighter escorts, the Americans began to suffer heavily when they attempted to engage targets deep in Germany. This eventually led to a crisis in October 1943. Caldwell and Muller note the significance of this break point, "Four full-strength missions in seven days—to Bremen, Marienburg, Munster, and Schweinfurt—had cost the Eighth Air Force 148 heavy bombers, 50 percent of its average daily operational strength. The American doctrine of unescorted daylight bombing was well and truly dead."[39] Recovering from this crisis required the development of long-range escorts and the ability to contest the Luftwaffe over German airspace.

As the P-51, newly equipped with the Rolls-Royce Merlin 61 engine, and other Allied escorts equipped with drop tanks were employed with greater numbers throughout late 1943 and early 1944, Luftwaffe attrition increased significantly.[40] These losses eventually overwhelmed the Luftwaffe. With the introduction of effective escorts, German fighter-aircraft attrition rose from 30.3 percent in Jan 1944 to 56.4 percent in March of that year.[41] By 24 May 1944, only 240 of the Luftwaffe's front-

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[39] Caldwell and Muller, *The Luftwaffe over Germany*, 137.
[40] William R. Emerson, "Operation POINTBLANK: A Tale of Bombers and Fighters," in *The Harmon Memorial Lectures in Military History, 1959-1987: A Collection of the First Thirty Harmon Lectures given at the United States Air Force Academy*, ed. Harry R. Borowski, Special Studies (Washington, D.C: Office of Air Force History, United States Air Force : For sale by the Supt. of Docs., U.S. G.P.O, 1988), 467.
[41] Richard Overy, "The Air War in Europe, 1939-1945," 49.

line, single-engine fighter force was operational.[42] As they steadily gained air superiority, the Allies had the freedom of maneuver to focus on the German aircraft industry, fuel refining, and critical supply lines that would further hamper German efforts to defend against the June 1944 invasion. As the Allied air offensive advanced eastward in the fall of 1944 and the spring of 1945, the Luftwaffe steadily lost its crews, aircraft, bases, fuel, and ultimately its capacity as a fighting force.

The Royal Air Force and US Army Air Force in the CBO

The following section examines the fallacy that the bomber would always get through; the doctrinal, technological, and cognitive flexibility that the Allied forces employed to overcome the challenge; and concludes with a discussion of the factors involved with overcoming the momentum of strategic-bombardment theory.

Surprise. The major surprise confronting British and American forces during the CBO was that the bomber did not always get through. Luftwaffe fighters and flak exacted heavy losses throughout the early years of the offensive, with October 1943 marking the turning point in the CBO. The RAF assessed that a strategic-bomber force would become "relatively ineffective" at a 7 percent loss rate and that operational effectiveness would be "unacceptably low" with 5 percent losses over a three-month period.[43] The losses of October 1943 greatly exceeded these estimates. Despite the large numbers of aircraft and aircrew that America and Britain could produce, the bomber offensive was unsustainable without long-range fighter escort. Recovering from this surprise required a shift in doctrine and technology, brought about by the infusion of creativity.

Recovery. Doctrinally, the early Allied bombing offensive suffered from a problem similar to that which had plagued the Luftwaffe during

[42] Kennedy, *Engineers of Victory*, 130.
[43] John McCarthy, "Did the Bomber Always Get Through?: The Control of Strategic Airspace, 1939-1945," in *The War in the Air, 1914-1994*, ed. Alan Stephens, American (Maxwell Air Force Base, Ala: Air University Press, 2001), 79.

the Battle of Britain. The RAF and USAAF disagreed on the optimal methods and primary targets of strategic-bombing. The British understood the costs of penetrating defended airspace from early in the war and consequently chose to strike only at night, accepting the inaccuracies of area-bombing. In contrast, American forces trained in the concept of high-altitude, daylight precision bombing focused efforts on key nodes in Germany's industrial economy. Due to the inability to rectify this doctrinal disagreement, the early years of the bombing offensive were better characterized by catch phrases such as "round the clock bombing," rather than an overarching construct from the Combined Chiefs of Staff.[44]

An important doctrinal adaptation occurred in mid-May 1943 with the creation of the Combined Bomber Offensive Plan. The plan codified target priorities as Luftwaffe fighters, submarine yards and pens, German aircraft industry, anti-friction bearing factories, and petroleum refineries.[45] This shift produced valuable unity of effort; but as Caldwell and Muller argue, mounting attrition rates throughout the summer and fall of 1943 made the requirement for long-range fighter escorts glaringly apparent. Drop tanks were pushed into testing, production, and fielding throughout the summer of 1943, but one of the most important events taking place simultaneously was the serendipitous development of the P-51.

Originally designed as a low-level fighter, the P-51 was equipped with an Alison engine. It performed adequately at low altitudes, but compared poorly to the more powerful P-38 and P-47.[46] In April 1942, as the RAF took delivery of its P-51s, the service called in test pilot Ronnie Harker to troubleshoot the aircraft's substandard performance. After flying the Mustang, Harker speculated that the P-51 would perform

[44] Caldwell and Muller, *The Luftwaffe over Germany*, 88.
[45] Caldwell and Muller, *The Luftwaffe over Germany*, 88.
[46] Kennedy, *Engineers of Victory*, 121.

much better if equipped with a Rolls Royce Merlin 61 engine.[47] Rolls Royce engineer Witold Challier also produced documentation that argued a Merlin powered Mustang would outperform the Spitfire at all altitudes up to 40,000 feet.[48] Somewhat fortuitously, the Merlin 61 could fit into the fuselage of a P-51 without any major design modifications.[49] The American Air Attaché in London, Major Tommy Hitchcock flew a Merlin equipped P-51 in October 1942 and quickly reported to American air leaders that it was one of the best, if not the best fighter aircraft developed by that point in the war.[50]

Despite its promising performance characteristics, the Merlin equipped Mustang confronted numerous challenges in the United States. USAAF leaders failed to appreciate that the P-51 was superior at all altitudes and remained devoted to the P-38 and P-47. Additionally, because the Mustang had first been ordered by the RAF and thus not vetted through the typical American acquisition process, key members of the Air Production Board questioned whether the reported performance characteristics were accurate.[51]

As the air situation over Europe worsened throughout 1943 General Henry "Hap" Arnold directed an inquiry into the development of all escort fighters.[52] In July 1943, performance tests at Eglin Field validated that the Merlin equipped P-51 was indeed superior to its German counterparts.[53] These tests created more advocates, and Allied leaders began to increase the Mustang's production and fielding. As P-51 squadrons were deployed in larger numbers and equipped with drop

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47 Kennedy, *Engineers of Victory*, 122.
48 Kennedy, *Engineers of Victory*, 122.
49 Kennedy, *Engineers of Victory*, 122.
50 William R. Emerson, "Operation POINTBLANK: A Tale of Bombers and Fighters," 465.
51 Kennedy, *Engineers of Victory*, 123–124.
52 William R. Emerson, "Operation POINTBLANK: A Tale of Bombers and Fighters," 465.
53 William R. Emerson, "Operation POINTBLANK: A Tale of Bombers and Fighters," 465–466.

tanks their large combat radius and superior performance were welcome additions to an offensive on the brink of failure.

An important doctrinal shift accompanied this technological change. In January 1944, the new commander of Eighth Air Force, Major General James "Jimmy" Doolittle, ordered that Allied fighters "should be encouraged to meet the enemy and destroy him rather than be content to keep him away."[54] Rather than surviving through evasion, the Allied offensive would confront the enemy head-on.[55] This cognitive flexibility turned out to be one of the most important command decisions in the Allied campaign to gain air superiority over Europe before D-Day.[56] For General Doolittle, the most important task was destroying the Luftwaffe fighter force with all available means.[57] With the extended range that Allied fighters gained from extra fuel and the introduction of the P-51, the Luftwaffe could no longer wait until Allied escorts had returned to their bases to attack bombers. They now faced Spitfires and Thunderbolts west of the Rhine and Mustangs, which by early 1944 had the reach to challenge them over the interior of Germany, east of the Rhine.[58]

Technological-Doctrinal Relationship. At the start of WWII, strategic-bombing was an alluring concept based on unproven technology. Translating this concept into reality required a doctrinal pull to develop sufficiently capable technology. As long-range, high-altitude bombers came on line, these efforts gave the Allies an important strategic tool with which to project power into Fortress Europe. By October 1943, however, it was clear that the faulty assumption regarding the bomber's ability to get through had brought the Allied air offensive close to failure. To address the problem, the Allies reoriented strategic-bombing's

[54] Caldwell and Muller, *The Luftwaffe over Germany*, 150.
[55] Caldwell and Muller, *The Luftwaffe over Germany*, 167.
[56] Caldwell and Muller, *The Luftwaffe over Germany*, 150.
[57] Caldwell and Muller, *The Luftwaffe over Germany*, 150.
[58] Kennedy, *Engineers of Victory*, 129.

doctrinal pull and established the requirement for long-range escort fighters.

The Allies recovered from the bomber's failure to get through, but it took several years, a significant level of attrition, and a fair amount of serendipity to make the required adaptations. From July 1942-May 1945, RAF Bomber Command lost 2,278 aircraft to fighters and 1,375 to flak. During a similar period, Eighth Air Force lost 2,452 bombers to fighters and 2,439 to flak.[59] As this evidence indicates, a doctrinal pull can be an effective technological-doctrinal relationship, but one must continually assess whether the context and assumptions that support the doctrine remain valid.

Summary Insights. Recognition of the fallacy of the assumption that the bomber would always get through came slowly. Recovering from that surprise and ultimately achieving air superiority required doctrinal, technological, and cognitive flexibility. It is important to note, however, that these shifts would not have been possible without sufficient time and capacity to withstand the attrition, as well as develop new capabilities. Paul Kennedy notes that the Allies benefitted from availability of reinforcing squadrons, "while the Luftwaffe suffered a catastrophe from which it never recovered."[60] Despite heavy costs, the Allies had the time and capacity to adapt to the mistake of having applied "too little, too early."[61] Although flexibility was indeed an important attribute for the Allies, we must understand the profound benefits that time and industrial capacity contributed to making these changes possible. By October 1943, the American airmen had come perilously close to obstinacy; fortunately for them, this mistake did not cost them the campaign.

The Luftwaffe's Defense Against the CBO

[59] John McCarthy, "Did the Bomber Always Get Through?: The Control of Strategic Airspace, 1939-1945," 77.
[60] Kennedy, *Engineers of Victory*, 129.
[61] Kennedy, *Engineers of Victory*, 109.

The following analysis examines the Luftwaffe's response to surprising material and electronic challenges to its air defenses, and argues German leaders struggled against doctrinal momentum in their efforts to develop sufficient doctrinal, cognitive, and technological flexibility.

Surprise. During its defense against the CBO, the Luftwaffe faced two major surprises. The first was its inability to stop the Allied air offensive after the introduction of long-range Allied escorts; the second was the devastating effect that electronic countermeasures had on aerial warfare. Caldwell and Muller argue the summer of 1943 represented a critical turning point for the Luftwaffe: "Until that time, the desire to mass airpower in pursuit of conquest drove German air strategy, production, and technological development. After July 1943, defense of home airspace became the Luftwaffe's overriding concern."[62] In January 1943, 59 percent German single and twin-engine fighters were in the west, with 25 percent on the Eastern Front. By January 1944, 68 percent of these aircraft were in the west, with 17 percent in the east; and by October 1944, German leaders shifted 81 percent to the west.[63] Early assumptions regarding the challenges of a long-range air offensive and the effectiveness of flak proved invalid when confronted with the Allies' determined and escalating efforts.

In addition to the physical battle of attrition in the air, an electronic battle was also taking place between scientists. Similarly to Britain, Germany undertook efforts to build an early-warning system and understood the requirement to guide fighters to attacking bombers, especially at night.[64] By May 1940, Germany had Freya radars, which were technically superior to Britain's Chain Home system, and provided

[62] Caldwell and Muller, *The Luftwaffe over Germany*, 94.
[63] Richard Overy, "World War II: The Bombing of Germany," 119–120.
[64] Gebhard Aders, *History of the German Night Fighter Force, 1917-1945* (London [etc.]: Jane's Publishing Company, 1979), 17.

coverage from Danish to the Swiss frontiers to a depth of 74.5 miles.[65] Germany also developed an extensive network of searchlights, listening posts, ground-control radars, and flak.[66]

The Germans understood as early as 1940 that radar technology was vulnerable to chaff and jamming.[67] This vulnerability was compounded when the crew of a Ju 88R-1 deserted to the British on 9 May 1943. The aircraft was equipped with a FuG 212 radar, which revealed that German surveillance and night-fighter radars worked on the same frequency.[68] Although the British had been researching chaff and had the opportunity to employ it in 1942, they intentionally reserved its use until 1943 in order to strengthen their systems against its effects.[69]

On the night of 25 July 1943, 791 bombers were sent to attack Hamburg. The Germans gained awareness of the raid based on favorable weather conditions and radio intercepts. But as soon as the attacking aircraft came within radar-acquisition range, chaff neutralized the ground radars. The raid was devastating, and German night-fighters and flak shot down only 1.5 percent of the attackers. British jamming, combined with chaff's effects on fire-control and air-reporting systems, disrupted the entire night-fighting system.[70] From this point forward, German night-fighting efforts were forced to react to British initiative. The Luftwaffe regained ground by 1944, but most of its technological advances were good for only a few days.[71] Aders notes that as the Allied offensive continued, the German night-fighter force could be compared to

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[65] Aders, *History of the German Night Fighter Force, 1917-1945*, 22.
[66] Aders, *History of the German Night Fighter Force, 1917-1945*.
[67] Aders, *History of the German Night Fighter Force, 1917-1945*, 80.
[68] Aders, *History of the German Night Fighter Force, 1917-1945*, 80.
[69] Aders, *History of the German Night Fighter Force, 1917-1945*, 80.
[70] Aders, *History of the German Night Fighter Force, 1917-1945*, 95.
[71] Aders, *History of the German Night Fighter Force, 1917-1945*.

"a badly battered boxer swinging desperately in the hope of scoring a lucky hit on his opponent."[72]

Failure to Recover. Although air defense had been prioritized at a lower level than development of offensive capabilities during the inter-war era, the Luftwaffe developed a comprehensive manual on air defense in 1935. Caldwell and Muller note that "Luftwaffe Manual 16: Conduct of Aerial Warfare" covered topics such as command arrangements, cooperation between fighters and flak, the importance of communications, and the requirement for tactical and operational flexibility.[73] But this doctrine still relied on offensive action to augment air defense efforts. The manual stipulated that the danger of an air attack could not be opposed by defensive measures alone and that "this danger…requires that the air force carry out offensive action against the enemy's air force in his own territory."[74] Demonstrating the gravity of this point, Aders argues, "During the formative stages of the Luftwaffe, air defense was neglected in favor of the offensive formations, without however creating a weapon suitable for strategic war. At the same time, the possibility that a strategic air force could penetrate deep into the Reich territory was completely overlooked."[75]

In other words, before 1939 the Luftwaffe had failed to make robust, centralized air defense a priority. Recovery from this mistake was further complicated by the fact that in 1943 the Luftwaffe was involved in a four-front air war. Each theater demanded attention; but few, if any, air leaders had a comprehensive understanding of the situation.[76] This reality constrained the Luftwaffe's doctrinal and cognitive flexibility. Without the ability to shift assets, command organizations, and doctrine into an effective integrated air defense along the lines of the Dowding

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[72] Aders, *History of the German Night Fighter Force, 1917-1945*, 167.
[73] Caldwell and Muller, *The Luftwaffe over Germany*, 21.
[74] Caldwell and Muller, *The Luftwaffe over Germany*, 19.
[75] Aders, *History of the German Night Fighter Force, 1917-1945*, 218.
[76] Caldwell and Muller, *The Luftwaffe over Germany*, 289.

system, the Luftwaffe had little hope of achieving the unity of effort required to combat the weight of the CBO.

The Germans were also insufficiently flexible in their approach to technology. In terms of fighters, the Bf 109 and Fw 190 had already shown the limits of their capabilities by the end of 1942.[77] Although the Me 262 had been in design since the summer of 1942 and clearly exceeded the performance of all Allied fighters, the Germans had neither the time nor the economic capacity to test and produce sufficient quantities to influence the air war.[78] According to Caldwell and Muller, the Germans stuck with proven types for too long. This proved devastating because the Allies continued to develop advantages in technology, skill, and numbers.[79]

In terms of electronic capabilities that were so fundamental for guiding fighters to intercept bombers during night operations, multiple German radar systems relied on a single technology, long-wave radar. Although German scientists had experimented with centimetric radar early on, they abandoned it due to poor results based on unstable transmitters and receivers.[80] While long-wave radar was valuable for early-warning purposes, it provided less accurate target positions than short-wave technology. Accuracy in determining location was crucial for tactical engagements at night or in the weather. Furthermore, long-wave radar was also more susceptible to chaff and jamming.[81] The Germans discovered their vulnerability to chaff in the spring of 1940, but eliminating this weakness did not receive much attention until a large-scale experiment was conducted in March 1943.

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[77] Caldwell and Muller, *The Luftwaffe over Germany*, 65.
[78] J. Adam Tooze, *The Wages of Destruction: The Making and Breaking of the Nazi Economy* (New York: Penguin USA, 2008), 621.
[79] Caldwell and Muller, *The Luftwaffe over Germany*, 291.
[80] Aders, *History of the German Night Fighter Force, 1917-1945*.
[81] Kenneth Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, An Arco Military Book (New York: Prentice Hall Press, 1986), 119–122, 127.

Rather than increase research efforts to minimize this vulnerability, Hermann Göring ordered strict military secrecy about all radar devices and any associated research. Göring feared details of the vulnerability would leak and that the Allies would quickly adopt the capability. Göring's directives essentially stopped the work of finding a counter to chaff.[82] Aders notes this decision was profound, "…a single means of jamming could neutralize the Luftwaffe air reporting service, Flak control and air intercept radars."[83] The consequences were evident in the raid on July 1943 raid on Hamburg and in the night-fighter force's continued inability to achieve decisive effects despite ending the war numerically stronger than it began.[84]

Technological-Doctrinal Relationship. Richard Overy argues, "One of the most significant things about air warfare was its close correlation with a certain level of economic and technological achievement."[85] War in the air requires close contacts with scientific researchers, advanced technology, sound military-civilian organization, rational industrial methods, and wide recruitment of non-military personnel.[86] This proved challenging to the Nazi regime with its social notions of exclusiveness and racial superiority. Overy eloquently states the implications of this dysfunctional ideology, "…the Axis power were caught at a stage where the nature of warfare and war technology made necessary the total commitment of social resources. In the air war, the inability to carry out such mobilization effectively was an important determinant of victory once Axis sights were raised to that of a world struggle."[87] German strategy and military doctrine required technology that could not only win wars quickly, but also continue to offset the vast resources the Allies

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[82] Aders, *History of the German Night Fighter Force, 1917-1945*, 80–81.
[83] Aders, *History of the German Night Fighter Force, 1917-1945*, 80.
[84] Aders, *History of the German Night Fighter Force, 1917-1945*, 220.
[85] Richard J. Overy, *The Air War, 1939-1945*, 1st ed, Cornerstones of Military History (Washington, D.C: Potomac Books, Inc, 2005), 2.
[86] Overy, *The Air War, 1939-1945*, 209.
[87] Overy, *The Air War, 1939-1945*, 211.

would bring to bear over time. The inability to produce and employ such technology in sufficient quantities or adequately adjust doctrine to account for these limitations were important factors in the outcome of the air war. Germany's interactive technological-doctrinal relationship proved well suited for the war's early years, but the failure to refine that relationship as the conflict widened significantly contributed to its ultimate defeat.

Summary Insights. As the weight of the Allied strategic-bombardment offensive increased throughout 1943 and 1944, the Luftwaffe confronted the surprising limitations of its air defense doctrine. The momentum generated by its offensively oriented doctrine and Hitler's aggressive timeline proved too difficult to overcome. With insufficient doctrinal, cognitive, and technological flexibility, the Luftwaffe was unable to recover and mount a successful defense of the Third Reich. This consequently yielded the initiative to the Allies and gave them freedom of maneuver with which to prepare for the follow on offensives that would ultimately compel Germany's unconditional surrender.

Conclusions

As the success and failures outlined in these historical examples illustrate, the combatant that could effectively develop sound technology and doctrine, appropriately balanced with the nation's strategic context, while remaining flexible in both planning and execution, significantly enhanced its chances of victory. In advance of the Battle of Britain, the British made critical decisions to base their air defense on fighters, early-warning radars, and a robust command-and-control network. This foresight, combined with the doctrinal and technological flexibility that supported it, were crucial factors in Britain's successful defense. The Luftwaffe, on the other hand, failed to recognize the important differences in context between the combined-arms battles of Europe and the independent struggle for air superiority over England. Limited in time and with insufficient doctrinal, cognitive, and technological flexibility, the

Luftwaffe's offensive against Britain failed. As the Allies shifted to the aerial offensive in the CBO, Bomber Command and Eighth Air Force suffered heavy losses; but they survived long enough for doctrinal, cognitive, and technological flexibility to generate the advantages required to prevail. Similar to its offensive failure in the Battle of Britain, the Luftwaffe's defense of the Third Reich was plagued by a lack of doctrinal, cognitive, and technological flexibility. As we look back on these examples for lessons it is clear that these were monumental struggles in the unique context of total war. They do, however, offer important insights as to the value of foresight, flexibility, and pragmatic grand strategy.

Robin Higham argues that one of the most important lessons of the Battle of Britain was "…the need to keep clearly in mind the short-term objective so that the long-term would remain an option."[88] The same could be said of the Combined Bomber Offensive. The ability to operate effectively in contested airspace is admittedly a short-term objective, but without it, it may be impossible to achieve long-term objectives. As the Joint Force struggles to organize, train, and equip for an uncertain adversary, this remains an important lesson.

[88] Robin Higham, "The RAF and the Battle of Britain," in *Case Studies in the Achievement of Air Superiority*, ed. Benjamin Franklin Cooling (Washington, D.C: Center for Air Force History, 1994), 171.

Chapter 3

The Battles for the Skies of the Levant

Adaptability is the law which governs survival in war as in life…

Sir B.H. Liddell Hart

Much like its contributions in WWII, airpower played a vital role during the Arab-Israeli conflict. This chapter's two historical examples, the Yom Kippur War and Operation Mole Cricket 19, add important evidentiary value to the previous chapter's analysis. These two examples contrast successful defenses with successful offenses and highlight the increased role surface-based defenses have come to hold in contested air operations. Similarly to the previous chapter, the analysis of each conflict opens with a brief description of the battle's context and turning points. Each section is then divided into analysis of the surprise the belligerent confronted, its efforts to recover, and a description of that force's technological-doctrinal relationship.

During the Yom Kippur War, the Egyptian and Syrian air defense forces combined strategic surprise with Soviet surface-to-air-missile (SAM) technology to impose punishing costs on the IAF during the opening days. The Israeli offense struggled during the opening exchanges because military doctrine failed to develop sufficient flexibility to combat realities at odds with fundamental political and tactical-planning assumptions. The stiff penalties paid by the IAF during the early portion of the Yom Kippur War can be contrasted to the successful Bekaa Valley offensive of Operation Mole Cricket 19. Incorporating lessons learned from the failures of 1973, the IAF combined strategic initiative with revitalized technology and doctrine to overwhelm the

Syrian SAM layout in 1982. It is evident from its significant defeat that the Syrian defense was technologically and doctrinally unprepared to counter the surprising fog and friction imposed by the IAF's multi-dimensional offense. Similarly to those of the last chapter, these examples emphasize that successful combatants account for their nation's strategic context while combining flexible operational art with sound technology and doctrine.

The Yom Kippur War

Israel lacks strategic space and has a small, but educated, populace. Given its inability to field a large standing army and the hostile character of relations with neighboring Arab states, Israel has sought to develop a qualitative advantage to combat neighboring states' quantitative superiorities. Key to this strategy has been developing an Israeli Air Force (IAF) that could defend the nation while reserve forces mobilized, with the additional ability to project power quickly throughout a region well suited for airpower.[1] The IAF's overwhelmingly successful preemptive attack during the Six Day War in 1967 demonstrated the value of a strong air force for national defense. The War of Attrition during 1969-1970 was a far less decisive conflict and the IAF began to suffer losses against the new threat of SAMs. Nevertheless, the relative strength of the IAF compared to neighboring air forces helped shape Israeli defense doctrine throughout the late 1960s and early 1970s.[2]

Egypt and Syria, by contrast, had larger, but more poorly educated populations and weaker economies. To address these limitations, these states relied on Soviet sponsorship for military training and technology. Although each fielded substantial air forces, Egyptian and Syrian air

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[1] R.A. Mason, "Airpower as a National Instrument: The Arab-Israeli Wars," in *The War in the Air, 1914-1994*, ed. Alan Stephens (Maxwell Air Force Base, Ala: Air University Press, 2001), 195.

[2] Amnon Gurion, "Israeli Military Strategy Up to the Yom Kippur War," *Air University Review*, October 1982, http://www.airpower.maxwell.af.mil/airchronicles/aureview/1982/sep-oct/gurion.html.

defenses relied heavily on Soviet SAM technology such as the SA-2, SA-3, SA-7, and SA-6, as well as antiaircraft-artillery (AAA) such as the ZSU-23/4. Although the IAF remained dominant in air-to-air combat, SAMs and AAA began to exact a significant toll during the War of Attrition. Air Vice Marshal Tony Mason notes that by August 1970, the IAF claimed a kill ratio of 40:1 in the air, but only managed 2:1 against SAMs and AAA.[3] By the fall of 1973, Egyptian air defenses along the Suez Canal consisted of 55 SAM batteries and AAA pieces that included SA-2s, SA-3s, SA-6s, SA-7s, and ZSU-23/4.[4] Syrian defenses consisted of approximately 25 SA-2s, SA-3s, and SA-6s, along with a mix of SA-7s and ZSU-23/4 AAA embedded with infantry units.[5]

In response to the rising challenge, the IAF began developing plans for preemptive attacks on the growing Egyptian and Syrian air defenses. Tagar 4 and Dugman 5 were pre-planned strikes against the Egyptian defenses along the Suez Canal and Syrian air defenses near the Golan Heights. Both plans relied on pre-strike intelligence for identifying the SAMs; good weather for locating the sites during the attack; and, most importantly, political authorization for a preemptive strike.

Campaign Narrative

When Egyptian President Anwar Sadat came to power in October 1970, he recognized that his nation was neither economically, nor militarily, equipped for continuous fighting against Israel.[6] In his search for a plan that could convince Israel to offer favorable peace terms, President Sadat recognized the situation required pressure from one or both of the super powers.[7] Although military action had only a limited chance of success, such action would garner the attention of the United

[3] Mason, "Airpower as a National Instrument: The Arab-Israeli Wars," 203.
[4] Meir Finkel, *On Flexibility: Recovery from Technological and Doctrinal Surprise on the Battlefield* (Stanford, California: Stanford Security Studies, 2011), 165.
[5] Finkel, *On Flexibility*, 165.
[6] Trevor Nevitt Dupuy, *Elusive Victory: The Arab-Israeli Wars, 1947-1974* (Dubuque (Iowe): Kendall Hunt publ., 1992), 387.
[7] Dupuy, *Elusive Victory*, 387.

States and Soviet Union.[8] Consequently, President Sadat made the decision in coordination with Syria to initiate a war with Israel in October 1973.

The strategic approach included simultaneous offensives with Egyptian forces attacking across the Suez Canal and Syrian forces penetrating the Golan Heights. An important aspect of this plan was to deny the IAF air superiority with dense SAM and AAA coverage, while making modest territorial gains before the Israeli reserve forces could mobilize. At that point, Egyptian and Syrian forces would prepare for tentative follow-on offensives, while political leaders sought a United Nations ceasefire to consolidate the gains.[9] Ultimately President Sadat recognized that any military successes would likely be limited, but this offensive would most certainly redirect the superpowers' attention to the stagnant Middle East peace process.[10]

The attacks began just after 2:00 p.m., on 6 October 1973. Israeli leadership received notification of the impending attack the day prior. The political situation, however, precluded taking preemptive action. During a pre-war meeting with Israeli Prime Minister Golda Meir, US Ambassador Kenneth Keating indicated that US support would be limited if Israel struck first. Consequently, Prime Minister Meir and Israeli Defense Minister Moshe Dayan decided that no preemptive attack should take place.[11]

The IAF initiated its offensive against Egyptian SAMs, Tagar 4, on the morning of 7 October. This effort was redirected, however, as Syrian ground forces began to overwhelm the northern Israeli Defense Force (IDF) divisions. Israeli leaders quickly ordered IAF units to move north to support the Golan Heights defensive and the Dugman 5 offensive against

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[8] Dupuy, *Elusive Victory*, 388.
[9] Dupuy, *Elusive Victory*, 390, 443.
[10] Dupuy, *Elusive Victory*, 387–388.
[11] Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany between the World Wars* (Ithaca: Cornell University Press, 1984), 28.

Syrian SAMs. In addition to the lack of authority for a preemptive strike, a lack of intelligence hampered IAF efforts. At the start of the conflict, the IAF had little technical information about the SA-6. Furthermore, the systems mobility made it challenging to locate, and inclement weather during the opening days of the conflict further compounded this challenge. The fog and friction generated from these circumstances exacted a toll of 40 IAF aircraft, or 14 percent of its front-line strength over the first two days of the conflict.[12] By the end of the first phase of the war on 9 October, Egyptian forces had made 5-10km gains to the east of the Suez Canal, while IDF forces had begun to push back Syrian forces on the Golan Heights.

The second phase of the war lasted from 10-13 October. Operations on the Sinai Peninsula were essentially at a stalemate, while IDF forces continued to make positive gains in the north against the Syrians. Consequently, the Syrians began to request additional pressure from Egypt in the Sinai in order to draw a portion of the IDF strength south. The Egyptian Commander, General Ahmed Ismail knew the value of his air defenses, but hesitated to risk valuable SA-6s on the east side of the Suez Canal with vulnerable bridgeheads.[13] Despite the risk, General Ismail ordered the offensive on 14 October in an attempt to maintain solidarity with his Syrian allies.[14] This offensive met with a stiff combined-arms Israeli resistance and failed. During the attack, Egyptian forces suffered 1,000 casualties and lost 260 tanks, while damaging no more than 40 Israeli tanks.[15]

The final phase of the war lasted from 16-24 October. During this period, the IDF mounted two counteroffensives eventually halting 10 miles from Damascus on 20 October and 40 miles from Cairo on 21

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[12] Brererton Greenhous, "The Israeli Experience," in *Case Studies in the Achievement of Air Superiority*, ed. Benjamin Franklin Cooling (Washington, D.C: Center for Air Force History, 1994), 591–592.
[13] Dupuy, *Elusive Victory*, 487.
[14] Dupuy, *Elusive Victory*, 485.
[15] Dupuy, *Elusive Victory*, 487.

October.[16] Cease-fire negotiations had begun after the failed Egyptian offensive on 14 October, and all sides formally agreed to terms on 25 October.[17] Militarily, the Egyptian and Syrian forces had been defeated; however, they gained valuable confidence and regional esteem for initiating and surviving an offensive against a more advanced foe. The IDF and IAF eventually carried the day, but they had sustained high losses in the conflict's early days.

The Israeli Air Force in the Yom Kippur War

The following section examines the strategic and tactical surprises that confronted the IAF, the service's efforts to recover using cognitive and doctrinal flexibility, and the momentum associated with previous success in Israel's technological-doctrinal relationship.

Surprise. On the morning of 6 October, as the IAF prepared to counter the impending attacks, a crisis developed. Israel had become increasingly dependent on the United States, and the Americans had made their opposition to Israeli preemptive strikes clear. This made the IAF's planned preemptive attacks on Egyptian and Syrian front-line air defenses were no longer suitable for the Israel's grand strategy, which in turn, conceded the initiative to the enemy.[18] Rather than quickly establishing air superiority as they had in the Six-Day War, the IAF had to balance efforts to establish freedom of maneuver in the air against support to Israeli ground forces.

As they conducted these efforts while confronting the strategic surprise, the IAF also faced tactical surprise. In 1973, the SA-6 was one of the most advanced Soviet SAM technologies available. The system was mobile, its radars employed advanced techniques that operated outside the Israeli electronic countermeasure (ECM) frequencies, and the missile

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[16] "Timeline of Yom Kippur War," *Jewish Telegraphic Agency*, accessed April 18, 2014, http://www.jta.org/1998/09/20/life-religion/features/timeline-of-yom-kippur-war.
[17] "Timeline of Yom Kippur War."
[18] Posen, *The Sources of Military Doctrine*, 29.

was difficult to track visually.[19] The system itself was very effective. When combined with ZSU-23/4s and SA-7s, it provided excellent coverage of horizontal and vertical gaps in the static defenses of the SA-2s and SA-3s. IAF pilots could previously ingress and egress at low altitude to avoid SA-2s and SA-3s, but now confronted an equally lethal threat when attempting to do so. Instead of simply reacting to a single type of missile as they had during the War of Attrition, IAF pilots now had to combat multiple threats simultaneously.[20] Aware of the threat, the IAF understood that locating and striking SAMs would be exceptionally important to establishing local air superiority, but the tactics and technology to do so required suitable weather. This limitation was of particular significance in the north, as poor weather hampered IAF efforts to locate mobile elements of the Syrian air defense during the war's early hours. By 9 October, the combination of strategic and tactical surprise cost the IAF approximately 14 percent of its front-line forces.[21]

Recovery. IAF efforts to recover from the initial setbacks imposed by strategic and tactical surprise required both cognitive and doctrinal flexibility. Confronting the early losses, IAF squadrons demonstrated cognitive flexibility by quickly modifying their tactics to include more fluid formations and attack profiles.[22] Creative Israeli leaders also developed hunter-killer techniques that exploited over-zealous SAM operators. Retired Commander of the IAF General "Motti" Hod was the air advisor for the northern front of the war and quickly noticed the high number of SAM launches. General Hod reasoned that the IAF could exhaust the number of available SAMs by employing a combination of false and genuine attacks.[23] These tactics were successful—the Syrians

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[19] Brererton Greenhous, "The Israeli Experience," 592.
[20] Macksey, *Technology in War*, 197.
[21] Brererton Greenhous, "The Israeli Experience," 591–592.
[22] Finkel, *On Flexibility*, 172.
[23] Brererton Greenhous, "The Israeli Experience," 591.

stopped shooting only three days into the war.[24] Examples of cognitive flexibility such as this were important; however, the doctrinal flexibility that resulted in the combined-arms offensive against SAM sites also proved critical.

Prior to the war, IAF doctrine relied heavily on air force efforts to combat SAMs.[25] The expectation was that air superiority was a precondition for a successful ground campaign, and the IAF would join a ground offensive after establishing air superiority.[26] Despite the strategic surprise, this sequence of events began to unfold on the morning of 7 October with an IAF offensive against Egyptian SAMs on the Suez Canal. Due to threatening gains by Syrian ground forces in the Golan Heights the IAF was quickly redirected to support the northern front. As noted previously, conducting these efforts without air superiority was costly; but this early air-to-ground intervention proved critically important to the war's outcome.[27] The combined-arms relationship also played an important role against Egyptian forces, but in this case Israeli ground forces provided critical assistance to the IAF. As the IDF initiated their counteroffensive on 14 October and eventually crossed the Suez Canal, Israeli ground forces overran and disabled several Egyptian SAM sites. This provided the IAF increased freedom of maneuver, which, in turn, increased IAF support to the ground offensive.[28] Neither of these examples was in accordance with established Israeli doctrine, but their contributions provided important lessons for the IAF as it recovered from the Yom Kippur War.

Technological-Doctrinal Relationship. Part of the IAF's success in the Six-Day War had been based on the effective management of an interactive technological-doctrinal relationship. Airpower and armored

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[24] Brererton Greenhous, "The Israeli Experience," 592.
[25] Finkel, *On Flexibility*, 178.
[26] Mason, "Airpower as a National Instrument: The Arab-Israeli Wars," 205.
[27] Mason, "Airpower as a National Instrument: The Arab-Israeli Wars," 205.
[28] Finkel, *On Flexibility*, 178.

forces were central to Israeli security doctrine, and the Israeli government supported each accordingly. By 1973, this system had developed momentum as it matured and achieved notable combat successes. As but one example of this mentality, Israeli Defense Minister Moshe Dayan was quoted on 10 August 1973 as saying, “The balance of forces is so much in our favor that it neutralizes the Arab considerations and motives for the immediate renewal of hostilities.”[29] Misled by the previously successful system’s momentum, Israeli leaders failed to account for changes in context that invalidated key assumptions. This led directly to the price exacted from IAF during the first three days of the Yom Kippur War.

Summary Insights. Israeli leaders recognized early in the state’s history that a strong air force was in important part of national defense. Airpower was an extremely effective tool in 1967, and Israel’s adversaries took note. Coupling the latest Soviet SAM technology with strategic surprise, Egyptian and Syrian forces were able to impose a significant level of attrition on the IAF during the first three days of the Yom Kippur War. Recovering from these losses required both doctrinal and cognitive flexibility. While the IDF and IAF ultimately prevailed, this experience serves as an example and warning of the dysfunctional momentum that a successful system can generate.

The Arab Air Defense Forces of the Yom Kippur War

The following section examines the surprising level of the IAFs recovery, the Arab force’s failure to recover from that surprise, and the doctrinal pull relationship that failed to develop the capability to conduct sustained offensive operations.

Surprise. The Egyptian and Syrian offensives started the Yom Kippur War with effective strategic and tactical surprise. By Day Three, however, they were confronted by the recovery of the IAF. Trevor Dupuy

[29] Dupuy, *Elusive Victory*, 406.

argues that despite the early losses described in the previous analysis, the IAF rapidly recovered from its initial setbacks and was fighting on equal terms by 9 October.[30] This proved particularly problematic for the Syrian offensive in the north as Israeli reserve forces mobilized and began to reverse early Syrian gains. By 11 October, the Syrians were asking Egyptian leaders to apply further offensive pressure in the Sinai in order to draw a portion of the northern IDF forces south. Egyptian leaders recognized that any further offensive in the Sinai would be operating outside the coverage of their air defenses, but they initiated the 14 October offensive based on a desire to assist the Syrians and preserve political solidarity that had been lacking in previous conflicts.[31] Expertly prepared IDF ground defenses and IAF attacks defeated the Egyptian advance and presented the opportunity to launch the Israeli counteroffensives that eventually threatened Damascus and Cairo by the wars end.[32]

Failure to Recover. Although their early efforts were notable, particularly when compared to previous combat experiences such as the Six-Day War, Egyptian and Syrian forces were unable to respond to the IAF's surprising recovery. Although equipped with substantial numbers of aircraft, Arab leaders expected neither the Egyptian nor the Syrian air forces to play a large role against the superior IAF. Thus, surface-based air defenses shouldered the main responsibility for blunting the IAF advantage. Running out of missiles three days into the war, Syrian SAM operators had little opportunity to demonstrate any level of flexibility they may have possessed. The Egyptians, on the other hand, had devoted significant time and resources to training for their offensive, and their early gains demonstrated the value of these efforts. However, as they confronted the requirement to project offensive power more deeply,

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30 Dupuy, *Elusive Victory*, 598.
31 Dupuy, *Elusive Victory*, 485.
32 Dupuy, *Elusive Victory*, 485–491.

there was insufficient doctrinal, cognitive, and technological flexibility to sustain another advance.

Any offense based on the SAM technology with which Egyptian forces were equipped required significant time and flexibility.[33] Only 20 of Egypt's SA-6s were mobile, and the remainder of its SA-2s and SA-3s were difficult to reposition for an offensive into the Sinai.[34] SA-2s and SA-3s along the Suez Canal were buried in concrete bunkers and arrayed in carefully prepared, symmetric sites based on precise calculations of coverage areas.[35] Any offensive advance that relied on surface-based air defense was required either to pause until air defense could be brought forward, or continue without air defense. Without the doctrinal, cognitive, and technological flexibility to reposition critical air defense assets rapidly, the Egyptian offensive was predictably limited in what it could accomplish against the professional IAF.

Technological-Doctrinal Relationship. After 1967, Arab leaders quickly prioritized developing doctrine and technology to mount an effective defense against the IAF. Three factors shaped these efforts: aircraft were significantly more expensive than SAMs; pilot training was lengthy and difficult in comparison to the training required to operate a SAM; and the Soviets were much more interested in supplying SAMs than aircraft.[36] Consequently, Arab forces relied heavily on surface-to-air defenses to neutralize the IAF's superiority. Based on the limited ability of their air forces and the practical utility of surface-based air defenses, SAM technology and tactics quickly generated significant momentum and shaped the Egyptian and Syrian air defense doctrine. As the Egyptian and Syrian forces prepared for their next conflict with Israel, it was clear that air defense would play an important role. What remained unclear, however, was how to incorporate this technology into

[33] Brererton Greenhous, "The Israeli Experience," 595.
[34] Mason, "Airpower as a National Instrument: The Arab-Israeli Wars," 204.
[35] Brererton Greenhous, "The Israeli Experience," 595.
[36] Mason, "Airpower as a National Instrument: The Arab-Israeli Wars," 201.

effective offensive operations. The momentum of air-defense technology and doctrine inherently limited what the Egyptian and Syrian offensives could hope to achieve without a more creative operational approach.

Summary Insights. Surprise was an important factor in the early Egyptian and Syrian successes of the Yom Kippur War, but neither force was prepared to confront the surprise generated by the IAF's quick recovery. Without sufficient doctrinal, cognitive, or technological flexibility the Arab offensives were limited in what they could accomplish. As Israeli reserves mobilized and the IDF quickly adapted combined-arms tactics, Egyptian and Syrian forces were eventually pushed back well inside their own borders. Although Arab leaders sought limited gains from the war and their military forces gained significant credibility, these profits came at a significant cost. Without a clearer understanding of the limits of air defense technology or a more creative doctrinal application of these critical assets, the Arab forces were inherently limited in what was possible. Nevertheless, this "draw" at the operational and military-strategic levels provided Anwar Sadat and the Egyptian armed forces sufficient political capital to make the Yom Kippur War a net plus for Egypt in the level of grand strategy.

Operation Mole Cricket 19

After the Yom Kippur War, nine years elapsed before Israeli leaders again called on the IAF to conduct major combat operations. Tensions between Israel and Palestinian Liberation Organization (PLO) guerrillas in southern Lebanon had been growing for some time. Although Egypt had signed a peace treaty with Israel in 1979, relations between Syria and Israel remained adversarial. During this period, Syria bolstered its border defenses with updated SA-6s, along with short-range SA-8s and SA-9s. The Syrian Air Force tripled in size and upgraded a portion of its fighter inventory to MiG-23s and MiG-25s. The IAF also modernized in the years after the Yom Kippur War and now possessed robust strategic and tactical C4ISR capabilities, modern fighters such as the F-15 and F-

16 equipped with stand-off precision weapons (PGMs), and advanced suppression of enemy air defense (SEAD) technology.[37]

Campaign Narrative

The Bekaa Valley is located near the Syrian border in eastern Lebanon, approximately 19 miles east of Beirut. In 1981, Syria began deploying SA-6s into the Bekaa Valley in order to assert its interests in the conflict between Israel and the PLO that was operating inside Lebanon.[38] General David Ivry, commander of the IAF from October 1977-December 1982, notes that this move threatened Israel's air superiority and ability to conduct air-to-ground operations near its border with Lebanon.[39] By June 1982, there were nineteen Syrian SAM batteries in the valley, fifteen of which were an improved variant of the SA-6.[40] On 3 June 1982, dissident Palestinian terrorists shot Israel's Ambassador to Britain.[41] In response, on 6 June the Israeli government initiated an invasion of Lebanon called Operation Peace for Galilee. The objective was to create a 25-mile security zone in southern Lebanon that would limit the PLO's ability to attack Israel.[42] IDF ground forces advanced along two parallel routes, one on the coast and the other through the Bekaa Valley and neared Beirut by 8 June. On this same day, Syria deployed an additional four SA-6s to the valley.

At approximately 1400L on 9 June, the IAF launched Operation Mole Cricket 19 against the Syrian SAM array in the valley. The operation was a highly coordinated attack incorporating standoff jamming, surface-to-surface missiles, long-range artillery, unmanned

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[37] Shmuel L. Gordon, "Air Superiority in the Israel-Arab Wars, 1967-1982," in *A History of Air Warfare*, ed. John Andreas Olsen (Washington, D.C: Potomac Books, Inc, 2010), 149; Mason, "Airpower as a National Instrument: The Arab-Israeli Wars," 208–209.
[38] Shmuel L. Gordon, "Air Superiority in the Israel-Arab Wars, 1967-1982," 148.
[39] Rebecca Grant, "The Bekaa Valley War," *Air Force Magazine*, June 2002, http://www.airforcemag.com/MagazineArchive/Pages/2002/June%202002/0602bekaa.aspx.
[40] Shmuel L. Gordon, "Air Superiority in the Israel-Arab Wars, 1967-1982," 149.
[41] Richard Holmes et al., eds., *The Oxford Companion to Military History* (Oxford ; New York: Oxford University Press, 2001), 67.
[42] Holmes et al., *The Oxford Companion to Military History*, 67.

aerial vehicles, as well as SEAD and strike aircraft. As the IAF began operations, Syrian combat air patrols returned to base in an apparent effort to minimize confusion for the SAM operators. In two major combined-arms attacks, the IAF destroyed 14 SAM batteries and damaged another five.[43] Shortly thereafter, the Syrian Air Force launched approximately 70 fighter aircraft to defend the valley. These efforts also failed to achieve a positive result, losing 28 MiG-21 and MiG-23s, and gaining no kills.[44] The active portion of the operation took only two hours to complete.

The Israeli Air Force Efforts in Operation Mole Cricket 19

The following section examines how the IAF's results in the Bekaa Valley operation were influenced by the surprise of the Yom Kippur War, the results of the nine-year recovery effort, and the value of a smoothly functioning technological-doctrinal relationship.

Surprise. Although the Bekaa Valley operation took place almost nine years after the Yom Kippur War, the strategic and tactical surprises of 1973 played a large role shaping the events of 1982. Israel suffered nearly 3,000 dead and more than 11,000 casualties during the Yom Kippur War. Dupuy notes, "In the October War, the Israeli loss rate, with respect to population, was more than 30 times as great as the American loss rate in World War II."[45] For the small state of Israel, these losses provided a sobering motivation to avoid repetition.

Recovery. The IAF devoted a significant amount of time and effort after the Yom Kippur War to organizing, training, and equipping to prevent incurring the losses of that war's early days. Recognizing the value of the combined-arms tactics that made significant gains during the Yom Kippur War, the IAF incorporated those ideas into doctrine and modernized its force to support a combined-arms approach. These

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[43] Shmuel L. Gordon, "Air Superiority in the Israel-Arab Wars, 1967-1982," 151.
[44] Brererton Greenhous, "The Israeli Experience," 600; Shmuel L. Gordon, "Air Superiority in the Israel-Arab Wars, 1967-1982," 151.
[45] Dupuy, *Elusive Victory*, 603.

efforts included the procurement of C4ISR, advanced fighter aircraft, multi-purpose tactical UAVs, and standoff PGM capabilities.[46] General David Ivri, commander of the IAF during the Bekaa Valley offensive, describes that the IAF trained and planned so that the effort was a "concert, rather than a dozen solos."[47]

Shmuel Gordon argues that most descriptions of the battle are unreliable, but judged Syrian Defense Minister General Mustafa Tlas' description to be objective. General Mustafa noted that a Boeing 707, Hawkeye E-2Cs, Skyhawk A-4s, UAVs, and ground stations conducted active and passive jamming of all detection, early warning, and control systems of the Syrian air defense. These efforts were augmented by 20-24 F-4s conducting active SEAD operations, as well as long-range artillery and surface-to-surface missile attacks on the SAM fire-control stations. The second portion of the attack, approximately 40 additional aircraft, began approximately fifteen minutes later and conducted strikes on SAM sites, headquarters, and other forces.[48] The result of the operation was an unqualified success and one of the most dramatic airpower victories in the late twentieth century.

Technological-Doctrinal Relationship. The efforts that led to the results of the Bekaa Valley Operation are an example of a smoothly functioning interactive technological-doctrinal relationship. Israeli leaders recognized the challenge that surface-based air defenses posed and in the aftermath of the Yom Kippur War focused on developing creative tactics, doctrine, and technology that could minimize these systems' ability to threaten airpower. The IDF remained committed to offensive maneuver warfare as its primary doctrine, but reemphasized the role of infantry, artillery, engineers, and other combat branches that

[46] Shmuel L. Gordon, "Air Superiority in the Israel-Arab Wars, 1967-1982," 151.
[47] Shmuel L. Gordon, "Air Superiority in the Israel-Arab Wars, 1967-1982," 151.
[48] Shmuel L. Gordon, "Air Superiority in the Israel-Arab Wars, 1967-1982," 150.

had been neglected under doctrine before the Yom Kippur War.[49] The IAF rededicated efforts to enhancing the capability to destroy an adversary's IADS at the outset of hostilities. As previously noted, this effort required the procurement of sophisticated fighter aircraft, remotely piloted vehicles (RPVs), precision and standoff weapons, and advanced electronic warfare systems.[50] In addition, these tools required the IAF to develop an advanced command-and-control system that could effectively orchestrate the multi-dimensional sensor-shooter system.[51] To ensure this system would perform when called upon, the IDF conducted clandestine operations to determine SAM frequencies and radar coverage, trained against mock SAM sites in the Negev desert for months before the operation, and employed RPVs to track the real-time location of mobile Syrian SAMs.[52] Ultimately, these efforts and their results during Operation Mole Cricket 19 demonstrated the IDF's adept ability to manage an interactive technological-doctrinal relationship and employ it to valuable operational and strategic effect.

Summary Insights. One of the hallmarks of the IDF and IAF is their high level of professionalism. Dupuy argues that the ability to conduct sound, objective analysis of historical experience and contemporary capabilities has been a large factor contributing to Israel's qualitative military advantage over its neighbors.[53] Such professionalism continued to be an important asset in the years between the Yom Kippur War and Operation Peace for Galilee. The IAF recognized that it could ill afford to be surprised again and that a significant part of the effectiveness of its combined-arms force depended on avoiding attrition

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[49] David Rodman, *Sword and Shield of Zion: The Israel Air Force in the Arab-Israeli Conflict, 1948-2012* (Portland, Oregon: Sussex Academic Press, 2013), 19.
[50] Rodman, *Sword and Shield of Zion: The Israel Air Force in the Arab-Israeli Conflict, 1948-2012*, 20.
[51] Rodman, *Sword and Shield of Zion: The Israel Air Force in the Arab-Israeli Conflict, 1948-2012*, 20.
[52] Grant, "The Bekaa Valley War."
[53] Dupuy, *Elusive Victory*, 600.

from SAMs. Equipped with revitalized doctrine and technology, the IAF proved more than capable when called upon in the Bekaa Valley.

The Syrian Efforts to Defend against Operation Mole Cricket 19

The following analysis examines the Syrian Air Force's surprise at the IAF's multidimensional offense, its inability to recover, and the technological-doctrinal relationship that hampered these efforts.

Surprise. As General Tlas' account noted, the IAF presented a multi-dimensional offense that started by jamming early warning, ground-control, acquisition, and fire-control radars. These efforts, combined with the kinetic SEAD strikes, effectively paralyzed the SAM array.[54] SA-6s had been able to operate outside of the effects of Israeli ECM during the Yom Kippur War; but by 1982, they no longer enjoyed such an advantage. Without accurate cueing and finding themselves sited in unfavorable terrain, SAMs in the valley had little ability to contest the airspace over the valley or defend themselves effectively once Operation Mole Cricket 19 began.[55] These same factors also limited the Syrian Air Force's subsequent defensive-counter-air effort. As 70 Syrian MiG-21s and MiG-23s rose to defend the valley, they essentially entered a "turkey shoot" against approximately 90 IAF aircraft.[56] By the end of the two-hour combined-arms offensive, the IAF had destroyed or damaged 19 of the 23 SAMs in the valley and downed 28 Syrian fighters without suffering any losses. The tactical and technological surprise that had served the initial Syrian offensive so well in the opening days of the Yom Kippur War proved just as devastating when employed by the IAF offensive in 1982.

Failure to Recover. In contrast to a multi-day campaign like the Yom Kippur War, time in Operation Mole Cricket 19 was extremely

[54] Shmuel L. Gordon, "Air Superiority in the Israel-Arab Wars, 1967-1982," 150.
[55] Brererton Greenhous, "The Israeli Experience," 599–600.
[56] Shmuel L. Gordon, "Air Superiority in the Israel-Arab Wars, 1967-1982," 152.

compressed. The level of localized opposition that the IAF strike generated on the afternoon of 9 June was unprecedented in airpower history up to that point. With insufficient preparation for the level of fog and friction that the IAF could generate, there was little the Syrian defenses could do to recover.

Although this problem was challenging, stagnant Syrian doctrine exacerbated it. Rather than developing a layered, in-depth defense such as that which had initially served the Egyptians so well in1973, Syrian SAMs relied too heavily on the SA-6, a platform that the IAF understood quite well by 1982.[57] Tactical and point-defense SAMs were valuable combat assets, but were limited in their ability to provide a comprehensive air defense. With insufficient cognitive and doctrinal flexibility to prepare for evolving IAF capabilities, the Syrian defenses were destined to pay a significant price in the next confrontation.

Technological-Doctrinal Relationship. As noted in the evaluation of the Arab forces in the Yom Kippur War, surface-based air defense technology had practical utility and promising combat capability. Thus, SAMs had an understandably large influence on the technological-doctrinal relationship in advance of the war in 1973. This relationship produced mixed results in the Yom Kippur War, and it is unclear as to the extent that Syria reevaluated this relationship in advance of its next contest with Israel. Syria recapitalized portions of its air defense, tripling the size of its air force and obtaining updated SA-6s, SA-8s, and SA-9s; but failed to develop the doctrine and technology to support a layered, redundant air defense. Although it could have been by design or simply oversight, the momentum of tactical SAM technology and doctrine placed Syrian defenses in an untenable situation as they confronted the IAF in 1982.

[57] Mason, "Airpower as a National Instrument: The Arab-Israeli Wars," 208.

Summary Insights. During the nine years following the Yom Kippur War, Syria recapitalized its air defense technology, but failed to revitalize its doctrine. Without sufficient foresight to prepare for the evolving capabilities of the IAF, there was little opportunity to recover from the overwhelming tactical and technological surprise of Operation Mole Cricket 19.

Conclusions

The final outcome of the decades-long Arab-Israeli conflict has yet to be determined, but the historical examples of contested air operations during the Yom Kippur War and Operation Mole Cricket 19 provide valuable lessons for contemporary contested-air operations. The Egyptian and Syrian offensives were able to combine Soviet SAM technology and training with strategic surprise and imposed formidable levels of attrition during the first days of the Yom Kippur War. Deprived of the initiative and blind to changes in context that violated critical planning assumptions the IAF was forced to rely on tactical and doctrinal flexibility to recover from its initial losses. These recovery efforts continued beyond the Yom Kippur War and a revitalized IAF quickly dominated Syrian air defenses in the Bekaa Valley during Operation Mole Cricket 19. The significant losses Syria incurred on the afternoon of 9 June 1982 were the price to be paid for being operationally and doctrinally unprepared to contest a technologically advanced, professional adversary.

The effects of surprise, the role flexibility in recovery, and characteristics of both effective and ineffective technological-doctrinal relationships during these contests offer insight for the Joint Force as it prepares for the future. These examples remind us that the successful combatants accounted for their nation's strategic context while combining flexible operational art with sound technology and doctrine.

Chapter 4

Comparing Historical Trends with the Contemporary Joint Operational Access Concept

What is the policy which your diplomacy is pursuing, and where, and why do you expect it to break down and force you to take up arms?

Sir Julian Corbett

The previous two chapters examined the roles of technology, doctrine, and flexibility in the Battle of Britain, the Combined Bomber Offensive, the Yom Kippur War, and Operation Mole Cricket 19. This chapter synthesizes the conclusions identified from those examples, summarizes the proposed US approach to projecting power in contemporary contested environments, and compares the contemporary concept to the conclusions of the analysis of the historical examples in order to identify areas requiring improvement. This analysis finds that the proposed contemporary concept detailed in the Joint Operational Access Concept (JOAC) offers a valuable starting point for countering the antiaccess/area-denial challenge, but that it requires refinement. The next iteration of the operational access concept must develop alternatives for a broad range of grand-strategic considerations, as well as increase its emphasis on developing the doctrinal, cognitive, and technological flexibility that have proven so valuable in previous contested-air operations.

Historical Trends

As the previously studied examples demonstrate, the challenge of projecting power through a contested domain is not new. The Battle of Britain, the Combined Bomber Offensive, the Yom Kippur War, and Operation Mole Cricket 19 represent combat between peer or near-peer adversaries who had the ability to contest freedom of action in the air.

These examples offer important insights that can help shape the contemporary concept for projecting power in contested domains.

Analysis of the historical examples highlights two conclusions. First, armed services must identify constraints, assumptions, and context that influence force structure, doctrine, and technology; accurately assess the implications of those factors; and act upon those implications. This is a fundamental step in understanding a force's ability to assist in the achievement of national security objectives. Successful forces, such as the RAF in the Battle of Britain, accurately assessed the impact of material constraints in advance of the war and adjusted their doctrines and technologies accordingly. In contrast, the IAF of the Yom Kippur War failed to recognize changes in political context that invalidated critical assumptions and incurred unplanned levels of attrition as a result. Similarly, Syria's stagnant air defense doctrine and technology failed to account for change and resulted in a one-sided defeat at the hands of a revitalized IAF during Operation Mole Cricket 19. In sum, without an understanding of the effects of constraints, assumptions, and context, on any given technological-doctrinal relationship, a force will almost certainly confront strategic, doctrinal, or technological surprise in its next war. Such surprise not only increases the level of attrition a force may suffer, but also potentially leads to defeat. The difficulty of recovering from such challenges leads to the second conclusion, the value of flexibility.

Surprise was a factor in each of the historical examples. Thus, doctrinal, cognitive, and technological flexibility proved to be critical attributes for overcoming that challenge. Forces with the flexibility to adapt, such as the Allies in the CBO and the IAF in the Yom Kippur War, suffered some attrition, but ultimately emerged victorious. In contrast, forces that failed to develop flexibility by focusing on a specific doctrine or technology achieved only limited success and were defeated. The Luftwaffe proved extremely effective at combined-arms offensive operations, but was too inflexible to translate this capability into a successful independent air offensive in the Battle of Britain. This shortcoming also plagued the Luftwaffe's defensive efforts to combat the CBO when the Allies introduced effective long-range escorts. Relying on SAM technology in 1973, the Egyptian and Syrian air forces found a cost-effective counter to the IAF; however, without doctrinal or cognitive flexibility, the Arab forces were unable to incorporate these critical capabilities into follow-on offensive operations. Developing doctrinal, cognitive, and technological flexibility is an art that takes time and dedication, but one that proved critically important in each of the historical examples under discussion.

The Joint Operational Access Concept

Identifying opportunities to incorporate the insights from this study's historical examples requires an understanding of the current threat environment and the proposed US approach for projecting power across contested domains. The Joint Operational Access Concept describes the contemporary threat environment and offers a potential solution. It defines operational access as, "the ability to project military force into an operational area with sufficient freedom of action to accomplish the mission."[1] Three contemporary trends promise to limit operational access: the dramatic improvement and proliferation of antiaccess/area-denial technology, the changing US overseas defense posture, and the emergence of space and cyberspace as increasingly important and contested domains.[2] Given these trends, establishing freedom of action in contested domains may be among the most difficult challenge US forces face in the coming decades.[3]

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[1] "Joint Operational Access Concept (JOAC)," 1.
[2] According to the JOAC, "Antiaccess refers to those actions and capabilities, usually long-range, designed to prevent an opposing force from entering an operational area. Area- denial refers to those actions and capabilities, usually of shorter range, designed not to keep an opposing force out, but to limit its freedom of action within the operational area." "Joint Operational Access Concept (JOAC)," ii.
[3] "Joint Operational Access Concept (JOAC)," ii.

Recognizing this challenge, the JOAC proposes a solution based on establishing cross-domain synergy. This idea is "the complementary vice merely additive employment of capabilities in different domains such that each enhances the effectiveness and compensates for the vulnerabilities of the others—to establish superiority in some combination of domains that will provide the freedom of action required by the mission."[4] Rather than relying on an advantage in any single domain, the goal is to generate a cumulative advantage across multiple domains. In certain aspects, this approach is an extension of the combined-arms operational art that the Germans and Israelis employed successfully in the past.

The basic operational approach starts with a pragmatic assessment of access requirements and designs follow-on operations to minimize access challenges.[5] To establish operational access, the Joint Force conducts cross-domain operations by seizing the initiative while deploying and operating on multiple independent lines of operation, exploiting advantages in one or more domains to disrupt or destroy antiaccess/area-denial capabilities in others, and creating pockets or corridors of local domain superiority to accomplish the required mission.[6] Capabilities and tactics fundamental to this concept include maneuvering directly against key objectives from strategic distance; attacking antiaccess/area-denial forces in depth, rather than a perimeter roll-back; maximizing surprise through deception, stealth, and ambiguity; disrupting the enemy's reconnaissance and surveillance capabilities while protecting our own; and defending our space and cyberspace capabilities while attacking the enemy's.[7] Although the concept of cross-domain operations is conceptually similar to combined-arms operations, achieving the desired synergy across greater distances

[4] "Joint Operational Access Concept (JOAC)," ii.
[5] "Joint Operational Access Concept (JOAC)," ii.
[6] "Joint Operational Access Concept (JOAC)," 17–21.
[7] "Joint Operational Access Concept (JOAC)," 22–27.

and additional domains will require greater levels of integration at lower echelons than previously developed.[8]

As this description suggests and the JOAC acknowledges, the concept of cross-domain synergy faces technological, tactical, logistical, and political challenges. Technologically, this approach to operational access requires a robust command-and-control system that can operate effectively in a degraded environment, combined with the ability to integrate fires and maneuver forces at great distances.[9] Tactically, joint interdependence requires a major investment in frequent, realistic training and sufficient strength to account for higher casualty levels than joint forces have suffered in decades.[10] These increases in strength employed along multiple, independent lines of operation impose significant lift and sustainment requirements.[11] It is important to note, however, that national policy may not support the JOAC's operational requirements. Political constraints may prevent preparatory action such as cyberspace operations or kinetic strikes deep into sovereign territory, and constrained defense budgets could prevent the acquisition of the required redundancies called for in the JOAC.[12] These issues create significant obstacles to the JOAC's proposed approach. Thus, comparing the JOAC with the conclusions drawn from the foregoing historical analysis should help identify areas for improvement.

Comparing Lessons of the Past to the Contemporary Concept

This study identified two conclusions from the historical examples. The first was the requirement to identify constraints, assumptions, and context that affect force structure, technology, and doctrine; accurately assess the implications of those factors; and act upon the implications. As noted above, the JOAC provides a fair assessment of these issues as it

[8] "Joint Operational Access Concept (JOAC)," 16.
[9] "Joint Operational Access Concept (JOAC)," 36.
[10] "Joint Operational Access Concept (JOAC)," 37.
[11] "Joint Operational Access Concept (JOAC)," 37.
[12] "Joint Operational Access Concept (JOAC)," 38.

highlights the technological, tactical, logistical, and political challenges of adopting the concept. The JOAC falls short, however, in that it neither assesses the implications of those challenges, nor specifies appropriate action to be taken in sufficient detail.

The JOAC's major shortcoming is that it is attempting to initiate a doctrinal pull without adequately addressing grand-strategic context. The concept is a set of tenets and requirements designed to shape the Joint Force's technology and doctrine for overcoming the antiaccess/area-denial challenge, but it provides policy makers with limited options. One of the biggest risks the document identifies is that national policy may not support critical preparatory actions.[13] Rather than offering an alternative approach, the JOAC advocates strategists "work with policy makers to ensure that operational requirements are clearly understood and accounted for."[14] Although a doctrinal pull can be an effective approach for developing technology and doctrine, in this case the JOAC's failure to provide policy makers with pragmatic options significantly decreases its viability.

An approach that could account for context while furthering efforts to solve the antiaccess/area-denial problem is to assess the situation as an interactive system and employ the logic of heterogeneous engineering.[15] Strategic planners can use heterogeneous engineering to identify the complex network of social, economic, political, and scientific forces affecting both the problem and solution.[16] The goal of this process would be to refine the JOAC to account for, and in some cases employ, these forces. Such an approach would help shape the concept so that it could be employed coherently with the other instruments of national power across a wide range of circumstances.

[13] "Joint Operational Access Concept (JOAC)," 38.
[14] "Joint Operational Access Concept (JOAC)," 38.
[15] John Law, "Technology and Heterogeneous Engineering: The Case of Portuguese Expansion," 106.
[16] John Law, "Technology and Heterogeneous Engineering: The Case of Portuguese Expansion," 106.

As it is currently written, the JOAC offers a military solution to the antiaccess/area-denial problem, but admits that it may be ill suited for the nation's political climate. The Joint Force must recognize, as Sam Tangredi argues, that an antiaccess/area-denial strategy is merely a subset of a grand strategy that includes diplomatic, political, and economic activities.[17] As such, leaders and strategists must continue to push technological and doctrinal boundaries to develop cross-domain military operations in such a manner they can be effectively incorporated into the larger grand-strategic plan for continuous advantage.

The second conclusion identified in the historical examples was the benefit of developing doctrinal, cognitive, and technological flexibility. The JOAC seeks to generate operational and tactical flexibility through cross-domain operations, but fails to offer practical guidance for institutionalizing other important types of flexibility. At the doctrinal and conceptual level, this would more rigorous professional military education (PME). Such PME would include a wider reading of history, detailed study of technological-doctrinal relationships, and a deeper understanding of the range of effects that can be achieved in all domains.[18] At the cognitive level, this means investing in frequent, realistic training in degraded environments. This type of training would provide commanders the opportunity to develop the mental flexibility to plan, recognize, and exploit effects being generated in other domains.[19] This also includes developing flexibility of mind in peacetime that can help the Joint Force refine its ability to learn and adapt quickly based on lessons learned across domains and services.[20] Developing technological flexibility includes efforts to prioritize redundant, versatile capabilities, while continuing to reform the acquisition cycle to be more responsive to

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[17] Sam J. Tangredi, *Anti-Access Warfare: Countering A2/AD Strategies* (Annapolis, Maryland: Naval Institute Press, 2013), 5.
[18] Finkel, *On Flexibility*, 3.
[19] Finkel, *On Flexibility*, 4.
[20] Howard, "Military Science in an Age of Peace," 7.

evolving and emergent requirements.[21] As Michael Howard noted over 40 years ago, the advantage in war frequently goes to the side that can more quickly adjust itself to a new and unfamiliar environment and learn from mistakes.[22] Flexibility is not a panacea; it does, however, provide important capacity to adapt to the unpredictable and unknown.[23]

Implications of Failing to Change

Antiaccess/area-denial strategies increase the amount of time required to complete an operation and promise to impose losses, therein increasing risk to the force attempting to gain access.[24] Developing an effective response to this challenge is central to national security. The JOAC warns that, "a military that cannot gain the operational access needed to bring forces to bear loses its utility as an instrument of national power."[25] Given the scope of its interests, the United States must develop a set of solutions to the antiaccess/area-denial problem that it can apply throughout the spectrum of conflict. Failure to address the shortcomings of the JOAC leaves the nation with a Joint Force ill-equipped to further national security. A viable approach to the antiaccess/area-denial challenge must account for variations in the political climate and develop the flexibility to adapt to surprise in all its forms. Such flexibility would not only help solve the immediate challenge, it would also further the nation's ability to generate a continuous advantage in whatever war it undertakes.

Conclusion

The JOAC provides an important perspective on the challenge of projecting power across contested domains, but the concept must be refined in light of the conclusions identified in the analysis of this study's historical examples. A force's ability to account for constraints,

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[21] Finkel, *On Flexibility*, 3; Richard P. Hallion, "Air and Space Power: Climbing and Accelerating," 380–381.
[22] Howard, "Military Science in an Age of Peace," 6.
[23] Howard, "Military Science in an Age of Peace."
[24] "Joint Operational Access Concept (JOAC)," 6; Tangredi, *Anti-Access Warfare*, 235.
[25] "Joint Operational Access Concept (JOAC)," 2.

assumptions, and context such as the political climate have significant influence on success and failure. The next iteration of the JOAC must account for these factors and articulate an approach in which the armed services can be employed coherently with the other instruments of national power across a broad range of circumstances. Another common factor pervasive among the historical examples was the almost absolute requirement for flexibility. A force's ability to adapt its doctrine, operational construct, and technology was essential for countering the effects of surprise. Although the JOAC proposes generating tactical and operational flexibility through cross-domain synergy, the Joint Force must also take steps to generate doctrinal, cognitive, and technological flexibility. Such steps include modifications to education, training, and the acquisitions process. Addressing these issues is no small task in an environment of endemic uncertainty and fiscal austerity; but the Joint Force must develop the capacity to complete these tasks. Doing so is fundamental to its ability to promote national security. As we search for optimal approaches to contemporary problems, we must remember and incorporate the hard-earned lessons of the past. As William McNeill advocated, this perspective will help make "simple solutions and radical despair both seem less compelling."[26]

[26] McNeill, *The Pursuit of Power*, viii.

Chapter 5

Conclusions

> *Theory cannot equip the mind with formulas for solving problems, nor can it mark the narrow path on which the sole solution is supposed to lie by planting a hedge of principles on either side. But it can give the mind insight into the great mass of phenomena and of their relationships, then leave it free to rise into the higher realms of action*
>
> Carl von Clausewitz

Military forces and technology share a close relationship. The proliferation of antiaccess/area-denial technology is once again altering the balance of forces in the world. Technologies such as modern IADS are becoming more robust, redundant, and difficult to penetrate. The proliferation of these threats and similar capabilities in other domains imposes significant challenges on a nation's ability to project power. Such challenges potentially degrade America's ability to achieve its national security objectives and support those of its allies.[1] It is thus imperative that the Joint Force develops an operational construct for penetrating antiaccess/area-denial defenses that is not prohibitive in either cost or risk. Meeting this challenge requires the ability to integrate capabilities fluidly across domains and among the instruments of national power.

This study employed a three-step construct to identify tenets that can guide the Joint Force's development of technology and doctrine for projecting power. The first step was developing an understanding of the importance and limitations of technology and doctrine, as well as the nexus of the two. The second step was to assess the role of technology and doctrine in past contested-air operations. The third step of this

[1] "Joint Operational Access Concept (JOAC)," ii.

process compared and contrasted the results of the historical analyses to the Joint Operational Access Concept in order to identify areas requiring improvement.

Summary of Findings

As with any complex subject, there are multiple perspectives on the importance and limitations of technology and doctrine, as well as the nexus between the two. Strategists can use three frameworks that describe technology's relationship to society to comprehend different types of relationships between technology and doctrine. Technological determinism, social construction, and interactive technological systems each offer valuable perspective on various aspects of technological-doctrinal relationships such as a doctrinal pull, a technological push, or an interactive process. Strategists who understand these relationships and effectively manage them will help develop and maintain an important dimension of flexibility that, in turn, will increase the Joint Force's long-term effectiveness.

Part of developing such flexibility and effectiveness includes identifying tenets to guide the Joint Force's development of technology and doctrine for the projection of power. This study furthered these efforts by examining historical examples of contested-air operations. In the Battle of Britain the British won the campaign for which they prepared, while the Germans lost, in part, due to a lack of strategic and operational flexibility. During the CBO, the Allies suffered heavy losses initially, but prevailed when doctrinal, cognitive, and technological flexibility gave sufficient emphasis to procuring and employing long-range escorts. Although the Luftwaffe's defense of the Third Reich against the CBO inflicted stiff penalties, the combination of Germany's expanding commitments and a continued lack of doctrinal, cognitive, and technological flexibility contributed significantly to defeat.

Flexibility was also an important theme in the Yom Kippur War and Operation Mole Cricket 19. In October 1973, the Egyptian and

Syrian offensives combined Soviet SAM technology and strategic surprise to impressive effect. The IAF was able to recover, however, demonstrating doctrinal and cognitive flexibility in the form of combined-arms operations and innovative tactics. In contrast, the Arab forces of the Yom Kippur War demonstrated insufficient doctrinal, cognitive, and technological flexibility; and the Arab's offensives stalled and failed once they attacked beyond the air defense coverage. In 1982, Israel exploited strategic surprise to devastating effect. The IDF had continued the recovery efforts that were begun during the Yom Kippur War. During Operation Mole Cricket 19, the IDF's modernized, combined-arms force devastated the Syrian air defenses in the Bekaa Valley. This success can be contrasted with the failure of the Syrian defenses to adapt to an evolving IDF. Syria procured additional aircraft and point-defense SAM systems after the Yom Kippur War, but failed to prepare for the type of offensive strikes the IDF was capable of waging. With insufficient doctrinal or cognitive flexibility to overcome the momentum of contemporary SAM technology and doctrine, the Syrian defenses of the Bekaa Valley failed catastrophically.

Principal Conclusions

The historical examples of this case study remind us that successful combatants have the ability to account for their nation's grand-strategic context, while combining flexible operational art with sound technology and doctrine. Synthesis of the lessons from each of these historical examples provides two tenets that should guide the Joint Force's development of technology and doctrine for penetrating antiaccess/area-denial defenses. First, the armed services must identify constraints, assumptions, and context that influence force structure, doctrine, and technology; accurately assess the implications of those factors; and act upon those implications. Second, doctrinal, cognitive, and technological flexibility are critical attributes for overcoming war's ever-present challenge of encountering the unexpected.

When one applies these conclusions to the JOAC, it is clear that the Joint Force must refine this operational concept. As the historical examples demonstrated, the next iteration of the operational access concept must develop alternatives for a broad range of grand-strategic considerations. The next iteration of the JOAC must address factors such as political restrictions on the use of force. The goal is to develop an approach in which the armed services can be employed coherently with the other instruments of national power across a wide range of circumstances. In addition, the Joint Force must increase its emphasis on the development of doctrinal, cognitive, and technological flexibility, rather than merely focusing on operational and tactical flexibility in the form of cross-domain synergy. These attributes will become ever-more critical as an increasing number of adversaries demonstrate the ability to contest operations in multiple domains. Addressing these challenges requires modifications to education, training, and acquisitions processes. Such modifications include broadening the study of history and cross-domain capabilities in PME, prioritizing frequent, realistic training in degraded environments, and reforming the acquisitions cycle to be more responsive to evolving and emergent requirements.

Leading such changes will be difficult; however, strategists armed with an understanding of the three technological-doctrinal relationships described in this study can overcome this challenge. The Joint Force must develop the ability to survive the unexpected and unpredictable, while cultivating a culture that can quickly innovate and generate new problems for adversaries. General Dempsey makes the strategic challenge clear: "the Joint Force must maintain the freedom of action to accomplish any assigned mission."[2] The reality is that 80 percent of the force structure to address the growing access challenge is already

[2] "Joint Operational Access Concept (JOAC)."

programmed or in existence.[3] This indicates that there will be an increasing demand for innovative and flexible solutions, with both the future and current force. Strategists must not only look to the future as we seek to ensure a continuous advantage, but also understand and incorporate the hard-earned lessons of the past.

[3] "Capstone Concept for Joint Operations: Joint Force 2020," iii.

APPENDIX

ACRONYM LIST

AAA	Antiaircraft Artillery
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CBO	Combined Bomber Offensive
ECM	Electronic countermeasures
IADS	Integrated Air Defense System
IAF	Israeli Air Force
IDF	Israeli Defense Force
JOAC	Joint Operational Access Concept
PGM	Precision Guided Munition
PLO	Palestinian Liberation Organization
PME	Professional Military Education
RPV	Remotely Piloted Vehicle
SA-	Surface-to-Air (prefix for FSU weapon system)
SAM	Surface-to-Air Missile
SEAD	Suppression of Enemy Air Defenses
SCOT	Social Construction of Technology

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